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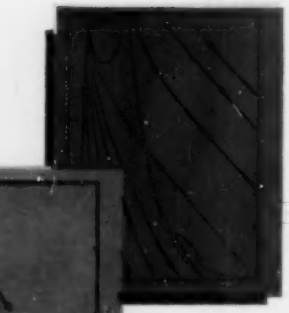

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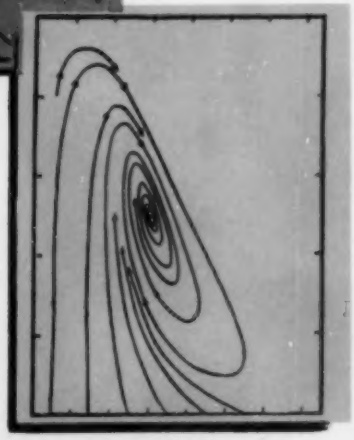

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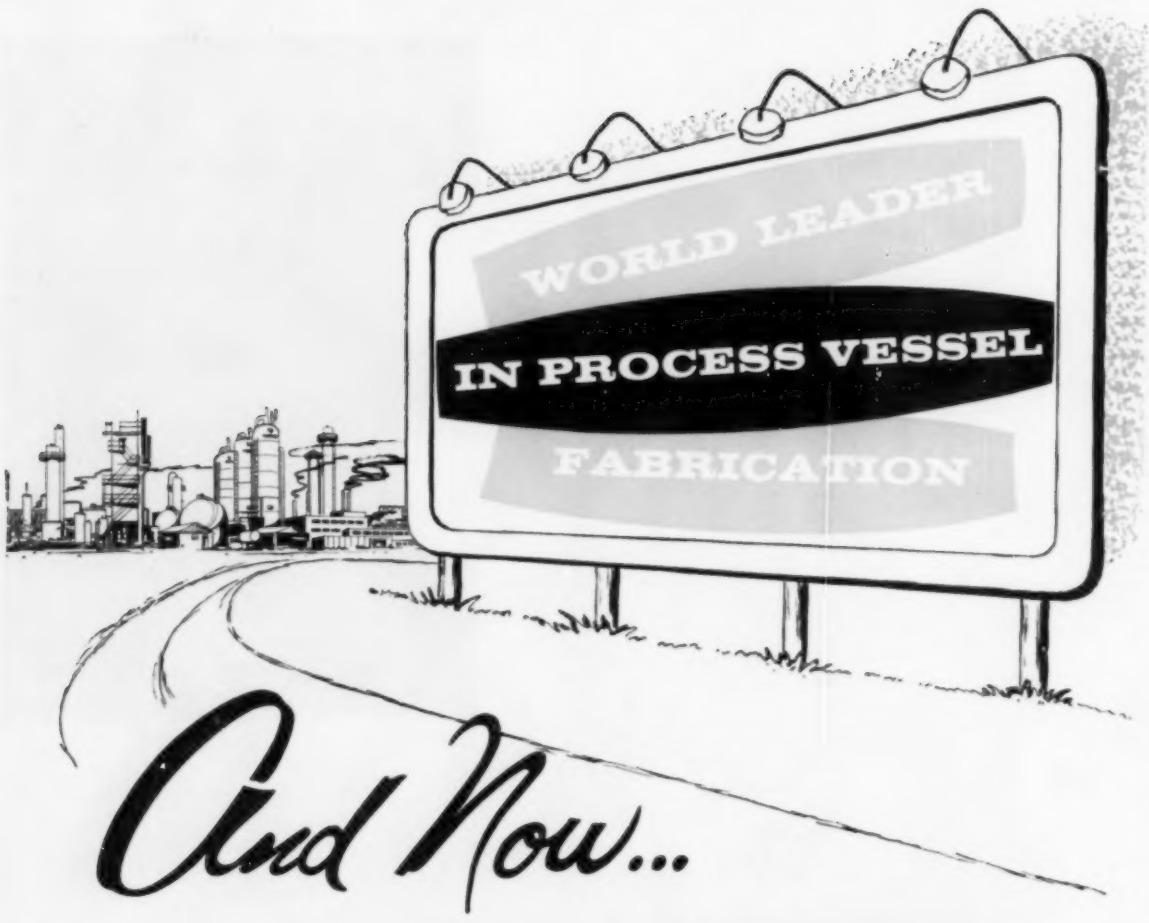

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Making your plans for process control

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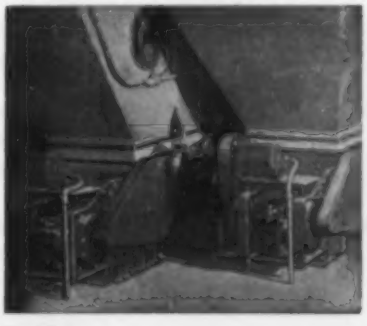

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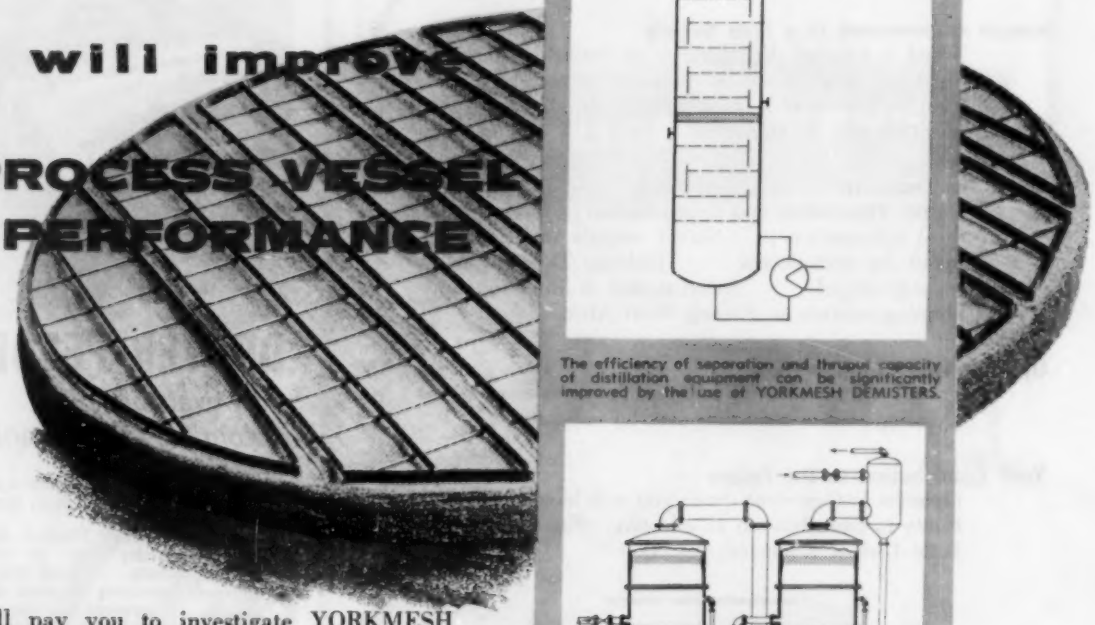

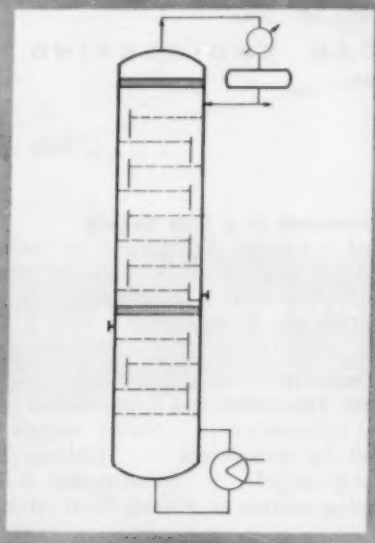

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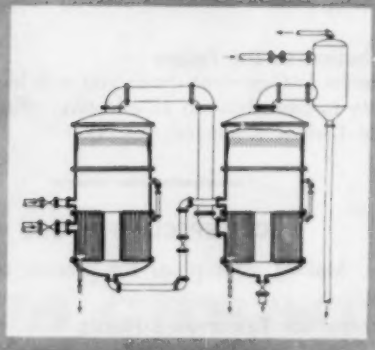

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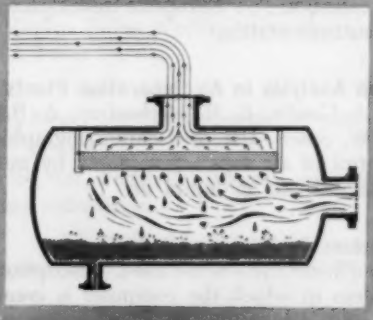

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Human achievement and the free society

CRAWFORD H. GREENEWALT,
E. I. du Pont de Nemours & Company

. . . it is surely obvious that the contributions of the chemical engineer are imbedded in virtually every aspect of man's technical effort. The comforts and conveniences of our homes, the food in our larder, the clothing and finery that we and our ladies wear, all acknowledge somewhere and somehow the contributions chemical engineering has made . . .

As a profession, we need bow to no other scientific discipline; scientifically, we have come of age. It is of significance also that our list of members includes not only eminent scientists, but a number who have advanced to important managerial posts. In our own company, I note with some pride the considerable number of our top executives who were trained in chemical engineering, and I have observed the same trend in other companies. I suppose, in the interests of strict scientific accuracy, I should not attempt to define cause and effect, but one could not seriously quarrel with the assumption that a chemical engineering education is a good preparation for high responsibilities of whatever character. If that is so, many corporate managements owe a considerable debt to our profession and, hence, to our Institute . . .

It is a fortunate circumstance that we do not have to visualize the precise shape of things to come to be able to predict with confidence many more decades of growth and prosperity, and, of course, of opportunities for chemical engineers. The past provides us with broad indications which are both sound and reliable, for as long as man's curiosity persists and the incentives to progress are provided, the scientific horizons will continue to recede, our material benefits will continue to increase, and any human needs that we are able to define will one day be met.

It makes little difference, in fact, what field of human endeavor we consider, whether it be science, the arts, the spiritual disciplines, or the secular affairs of men, our progress will depend on the maintenance of an atmosphere which will foster individual effort at its maximum level. It seems to me that such an atmosphere has two essential components: first, a maximum of opportunity for individual self-expression and, second, a maximum of incentives for achievement . . .

Of course, I would not deny either the existence of internal motivations or their strength as incentives to maximum effort. Surely there is much idealism in the world, and the motivations of the spirit influence every man and woman to some degree. And had mankind reached a sufficiently high spiritual plane, perhaps they would suffice as guarantees of high performance. Human nature, however, must be taken as it is, not as it should be, and I think people will continue to be responsive primarily to self-interest . . .

Fifty years ago, William James wrote an essay which he called "The Moral Equivalent of War." He noted the fact that the pressures of war invariably bring out abilities in individuals of which neither they nor their closest associates were aware. War, he said, inspires high personal courage, hardihood, and endeavor that might have lain dormant throughout an entire lifetime spent in a peaceful society. And war, through teamwork arising out of national necessity, brings into being accomplishments in the field of science and technology that might otherwise have not been realized for many years, if at all. Mr. James was an ardent pacifist, and, while deploring the futility and destructiveness of war, he realized its extraordinary effectiveness as an incentive to high individual performance. While anxious to eliminate the cause, he feared that, without motivations of equal strength, men and their societies would stagnate and "human life with no use for hardihood would be contemptible."

This was his basis for seeking a "moral equivalent of war"—a set of incentives sufficiently powerful to stimulate people in a peaceful world to efforts comparable to those of wartime.

I doubt that any thoughtful person can deny the validity of Mr. James' premise. Military conflicts have always given abundant examples of high courage, great daring, and superhuman accomplishment, and this not infrequently by individuals from whom such performance could not reasonably have been expected. In more recent years, as warfare has come to rely so heavily upon science, we have seen extraordinary technical advances brought about by the pressures and necessities of emergency . . .

War, as we know all too well, is completely futile, destructive, and immoral, but I think we must agree also that it has produced, perhaps as a completely unintentional by-product, some advances in material human progress which might not otherwise have been realized for years to come . . .

What then is the answer? Perhaps there can never be a direct equivalent. Perhaps people could not maintain their spirit for many years either under pressure of war or the pressure of fear. I suspect, in fact, that war—certainly modern war—is by its very nature a temporary phenomenon simply because humanity cannot for very long withstand its emotional demands.

There is, further, the fact that our objectives in time of war are proximate and immediate, while those to which we address ourselves in peacetime are of much longer range. And perhaps in this difference of goals we can perceive one possible answer.

On a basis of human achievement, the polygraph of recorded history is extremely erratic, so uneven, in fact, and so subject to confused distortion, that generalities are difficult. It is clear, however, that there have been, at various times and in various countries, periods which saw a great outpouring of achievement with an extraordinary number of superior men to leave the stamp of genius upon the pages of history. In each of these Golden Ages, for a time, some phenomenal fertility was induced into the soil of accomplishment. And diverse as were the conditions, there is one common element: The intellectual freedom essential to the creative process.

This, then, can well be the answer which eluded William James. In freedom, which often is the antithesis of the coercive drive of military emergency, we find the most effective environment for achievement yet devised by the human mind. Perhaps, over a

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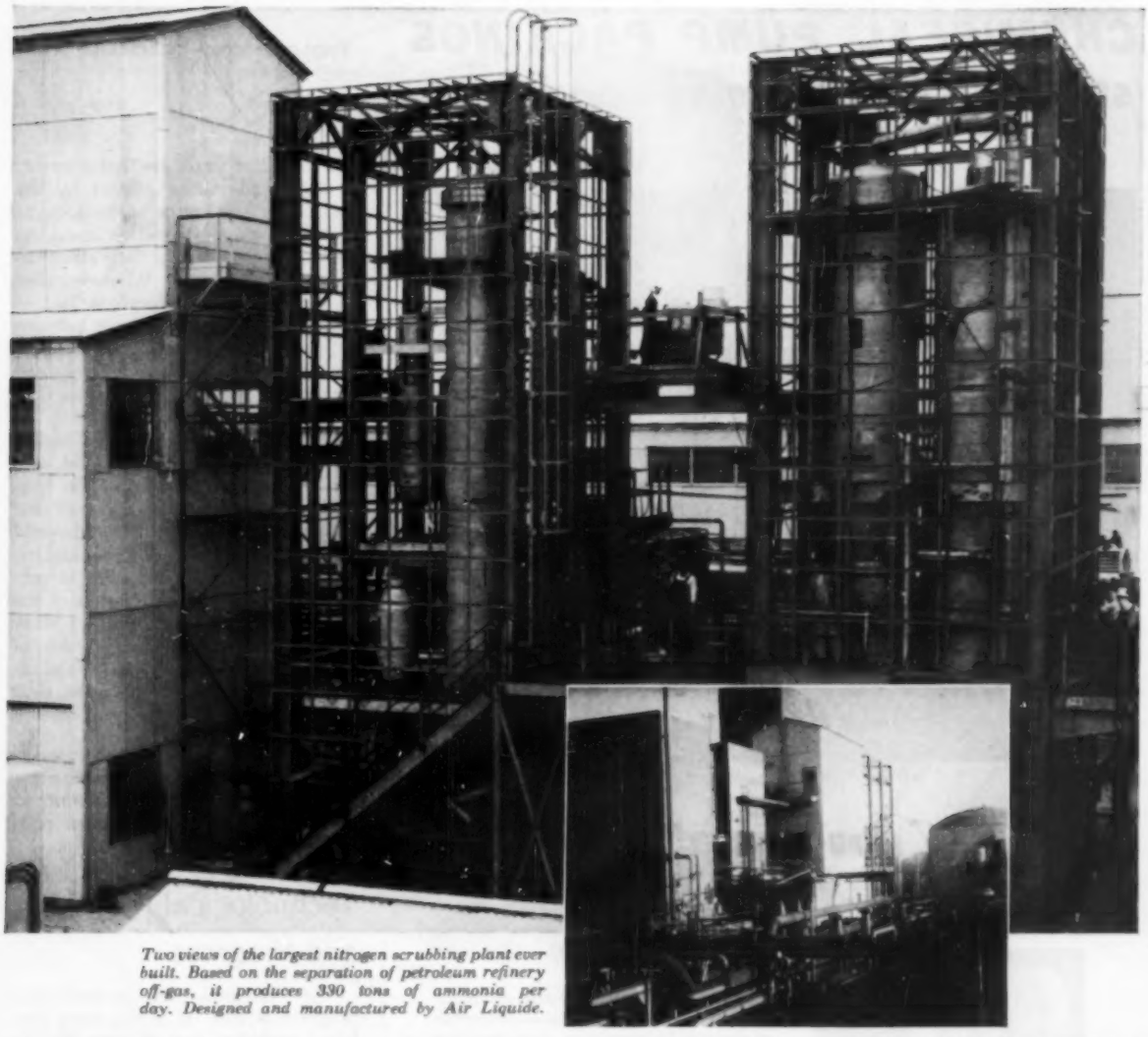

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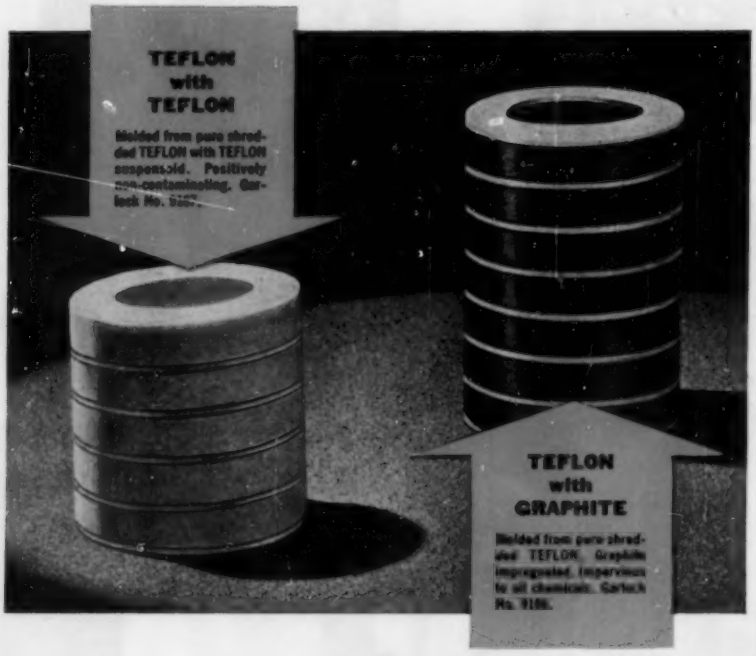
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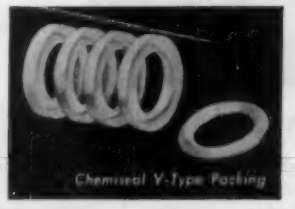

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noted and quoted

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long period of years, the inducements to high performance offered by the free society will not be as dramatic as those of war. On the other hand, no one can question either their effectiveness or their morality. Whenever men have been freed of coercion and of artificial restraints, they have outdone themselves in creative accomplishment, and the benefits have spread throughout the society in which they lived.

Fortunately, in the United States, the free society has survived and, as a result, we have flourished. The spiritual and material well-being of our people has been advanced far beyond that of any other society in history. We have dedicated ourselves to preserving the rights and liberties of the individual; we have provided an array of incentives to encourage each of our men and women to strive the utmost, and have guaranteed the right of each to retain the fruit of his striving.

Presented at the Fiftieth Anniversary Meeting of the American Institute of Chemical Engineers, Philadelphia, Pennsylvania, June 25, 1958.

Technological Promises and Progress

The stampede of technological progress is real; it is the most profound technical fact of your life. To ignore it would be like pretending the earth was flat to make the mathematics of navigation easier.

In an age of a stampeding technology we must find ways of accelerating our learning and thinking processes so that we may keep abreast of reality. Let's consider how the "horse" still dominates our thinking, after half a century of automobiles.

Consider the profound engineering principle that puts an automobile engine up front, so that you can have expensive complicated drive shafts, universals, and other mechanisms to deliver the power to the rear wheels.

Next time you stumble over the tunnel in the middle of your car, do it reverently—remember it is a "monument" to the memory of the horse that used to be up front.

How much longer can we afford to let horse-and-buggy thinking dominate in this age of stampeding tech-

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Tubexperience in action

X ray checks a critical weld

Precision welds of hafnium and Zircaloy plate in a costly reactor component go under X ray at Superior's Nuclear Products Division

*Nuclear reactor components—complex structures, control rods and channels—made from the reactive metals are extremely difficult to fabricate and usually represent many thousands of dollars in material and labor. Each end product must undergo thorough X-ray examination. Since we usually consider even the smallest defect cause to reject the entire unit, the workmanship called for is necessarily of the highest caliber. In addition, Superior has developed unique welding methods, special equipment and fixtures to make possible such precise fabrication.

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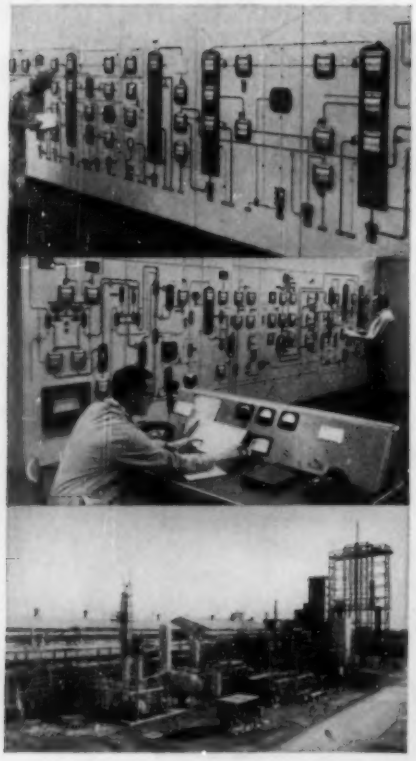

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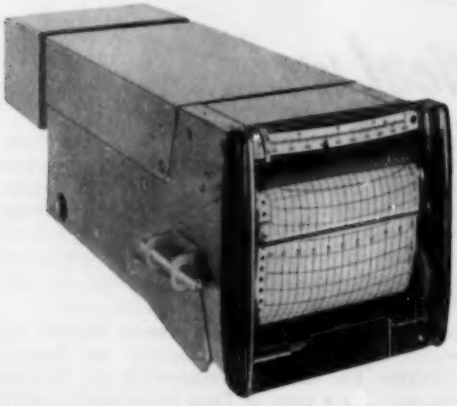


Each Consotrol Control Station consists of a Recorder with M/58 Controller integrally mounted at rear. Complete station pulls out from front of panel, as shown above.

SHOWN OPPOSITE is part of graphic control panel for cracking unit at Sun Oil Company, Marcus Hook, Penna. Complete panel instrumentation was supplied by Foxboro.

Not only by their unvarying dependability of control, but also through unusual economy of maintenance, Foxboro Consotrol Recording Control Stations have proved a profitable investment for Sun Oil Company at Marcus Hook, Penna.

Nearly two years ago, 129 Consotrol instruments were installed as complete instrumentation for the control rooms of the ammonia plant and the Houdriflow catalytic cracking unit in this modern Sun Oil refinery. In continuous operation ever since, not a single Consotrol Recorder or Controller has yet needed recalibration or realignment!

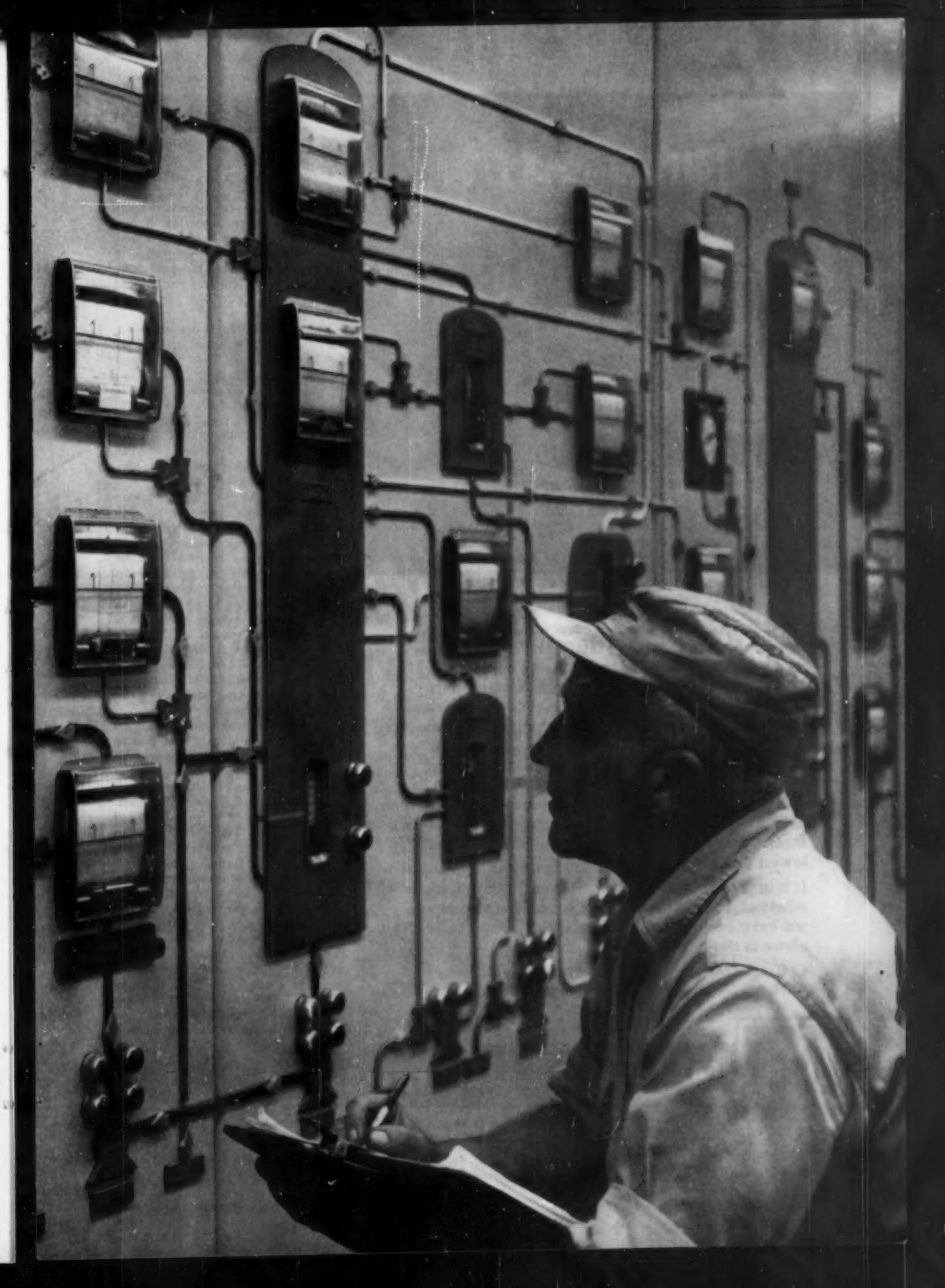
Add to this the fact that Consotrol Recorders need replacement of their full-scale, 4-inch strip charts as infrequently as once a month — re-inking only twice a year — and it's easy to understand why Sun Oil men at Marcus Hook are more than satisfied with Consotrol equipment.

Get the full story of these ultra-dependable Recording-Controllers before you design your next control system. Write for Consotrol Bulletin 13-18. **The Foxboro Company, 939 Neponset Avenue, Foxboro, Massachusetts.**

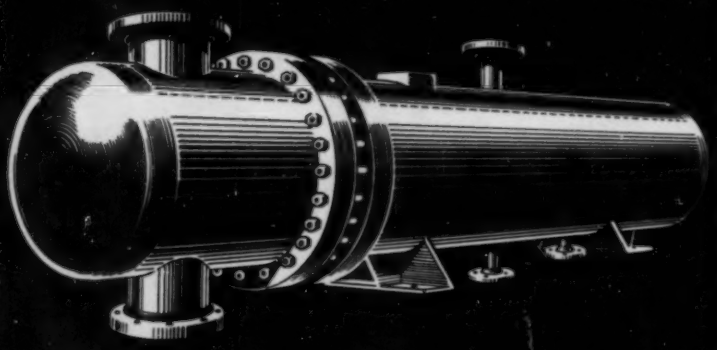
*Reg. U. S. Pat. Off.

FOXBORO CONSOTROL INSTRUMENTS

REG. U.S. PAT. OFF.



MANNING & LEWIS



M & L CARBON STEEL REACTIVATION CHILLER
made to A.S.M.E. code (Dimensions 18" outside diameter shell, 7' overall length, weight 2000 pounds)

Today's rapid strides in the technology of processing plant operation make it essential for a manufacturer of equipment to be "staffed up" with people who have had extensive training and experience. More than half our staff have spent a major part of their working life in this one field and have played a major role in the design and fabrication of many types of processing equipment. They know the limitations and workability of all metals and how to get maximum service from each. This accumulated knowledge of base materials and our extensive experience in design and fabrication means practical, trouble-free equipment at the lowest possible cost.

It is impossible, in a field requiring such wide diversification, to illustrate, or even list, all the products we have been called upon to supply. The chiller above is simply one among thousands.

Call on us the next time you need equipment. We are fully qualified to design and fabricate to all codes.

M&L MANNING & LEWIS

ENGINEERING COMPANY

Dept. B, 28-42 Ogden Street, Newark, New Jersey

DESIGNERS & MANUFACTURERS OF QUALITY HEAT EXCHANGE EQUIPMENT

noted and quoted

from page 8

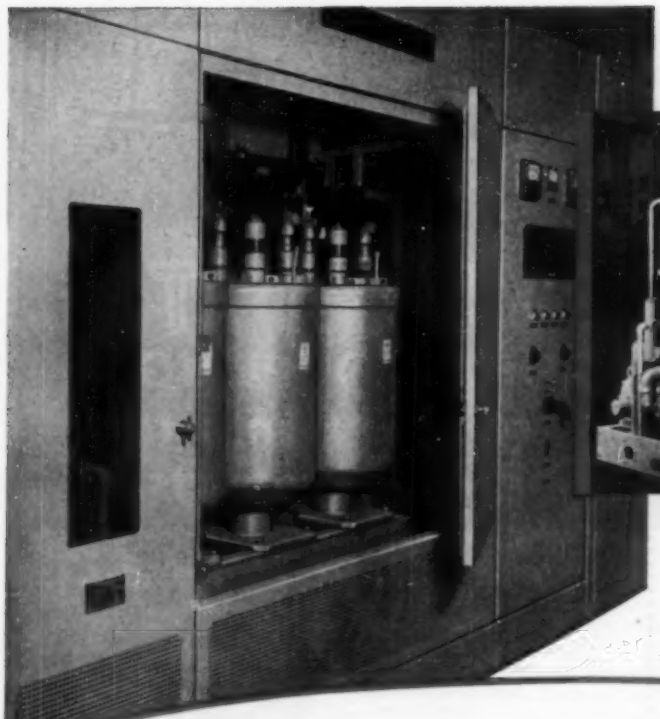
nology? Technology has outdistanced man's language and his imagination. For example: an appropriate descriptive term of a reference for nuclear devices has not yet been developed. To refer to a nuclear weapon as a bomb is as logical as it would have been to call the machine gun a rapid fire improved automatic bow and arrow.

Planners tend to suffer from a peculiar ailment. They always plan to fight the last one over. They are handicapped by experience.

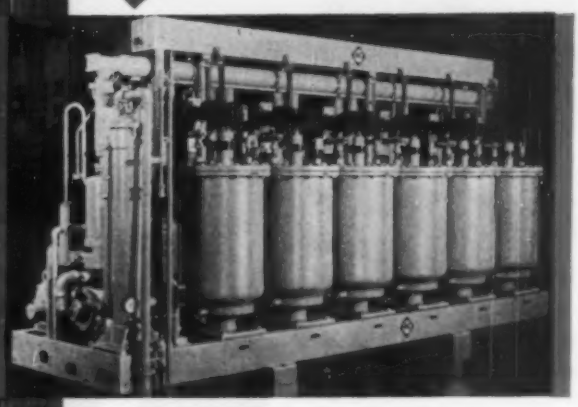
When I was a commuter in New York City, the first day I was 15 minutes early for my train. As the time went by, like all experienced commuters, I developed a contempt for arriving at the station before the conductor started yelling "board!"

Then came the day when I was two minutes late arriving at the Seventh Avenue entrance of Penn Station. I tore down the arcade passageway and was brought to a complete halt by the throng slowly struggling down the two crowded stairways. Then I spied the moving stairway going down; it was jammed and had a line waiting to get on it. No time to be gained there. I was doomed to miss my train. *Then I saw it!* The most deserted spot in Manhattan at 5 P.M.—the moving stairway going up! What I amateurishly thought was an original idea took hold of me. This was where I could gain that minute I needed. All I needed to do was hit that deserted moving stairway going the wrong way and hit it fast enough and I would gain the minute I needed. I reared back for a fast start, and lunged forward. The station came to a standstill—all experienced commuters instinctively turned to stare. They wanted to see how I would make out. They already knew how they had made out when they tried it. I hit the stairway with a rush, at first lunge I got about one third of the way down. The progress ground slowly to a standstill. Finally I learned a great and profound lesson. There are times in life when you have to go like the devil to stand still. Maybe that's the lesson that applies to the age in which we live.

Excerpted from Technological Promises and Progress ("The Collapse of Time")
Talk delivered by J. Lewis Powell, Office of Assistant Secretary of Defense (Supply and Logistics) before meeting of Drop Forging Association.



Open pumped tube unit permits easy access for inspection. Easy to recondition in field.



Enclosed sealed tube unit conserves space, cuts installation costs, eliminates need for vacuum pumping system.

ALLIS-CHALMERS

Mercury Arc Rectifiers

Pumped or Sealed? Open or Enclosed?

Here's how Allis-Chalmers can help you choose a rectifier for your job—

BOTH sealed and pump-evacuated tube rectifiers offer distinct advantages, depending upon the application. Whether your rectifier should be open or enclosed construction also depends on the application. Since Allis-Chalmers offers you a choice of sealed or pumped tubes in either open or enclosed construction, you get an unbiased recommendation, based on a study of your needs, and not on commercial expediency. And you can be sure of unsurpassed reliability and ease of operation, as proved in hundreds of Allis-Chalmers installations.

Only Allis-Chalmers Excitron Rectifiers give you all these important advantages—

- **Fixed excitation anode** does not contact mercury — is independent of level, turbulence or impurities.
- **Continuous excitation** eliminates need for reignition — pilot arc always present.
- **Grid phase control** located in clean region near anode where ion density is lowest.
- **Internal cooling system** provides high heat transfer with seamless tube coil.
- **Arc-over-free tube** eliminates arc-over danger by insulating entire arc path.
- **Enameled anode seals** provide high strength, trouble-free seal.

For detailed information on mercury arc rectifiers contact your nearest A-C office, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin, for bulletin 12B8494.

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A-3560

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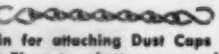


Chain for attaching Dust Caps on Dust Plugs to adapters or couplers

EVER-TITE COUPLING CO. INC., 254 WEST 54TH STREET, NEW YORK 19, N. Y.

NEWS PLUS INTERPRETATION

SCOPE

U. S. translation of foreign technical information

A foreign Technical Information Center, financed by a $510,000 appropriation to see it through mid-1959, is now operating within the Office of Technical Services, U.S. Dept. of Commerce.

Purpose of the Center is to maintain an up-to-date catalog of scientific and technical translations made by or through auspices of Government agencies, and to disseminate such translations to the public. The new TIC is an offshoot of the experience built up by OTS, which has since 1945 been collecting, cataloging and publishing reports resulting from U.S. Government-sponsored research.

TIC now offers abstracts of all articles appearing in 141 Soviet technical journals, on a single issue or subscription basis. Various sections of *Referativny Zhurnal*, the Soviet's own abstract journal, will be available initially as single issues, but subscriptions may be offered later. The Central Intelligence Agency's semi-monthly review of various areas of Soviet science, *Scientific Information Report*, will also be available on either a subscription or single-issue basis.

The Center expects to soon begin distributing complete translations of articles and books, Director John C. Green reports. Available material will be listed in an abstract journal which TIC expects to begin publishing in September.

Principal coordinator and supporter of the actual translation programs is the National Science Foundation, which is also presently expanding its operation. As a preparatory measure for an NSF-sponsored (Jan. 29-30, 1958) Conference on U.S. Science Abstracting and Indexing, NSF questionairred 14 major non-governmental Services to discuss ways and means for improving and speeding up coverage activities.

Chemical Abstracts reported its current rate of abstracts production at "100,000/yr., from 7,500 journals and 2,000 books and including patents from 22 countries." Covering all "branches of chemistry, CA reported: "No specific blocks of published chemical information known to be missed . . . constant expansion necessary, of course, to keep up with growth of chemical field."

Engineering Index, which functions through the Engineering Societies Library, reported processing "about 27,000 annotations/yr. from some 1,400 periodicals and an indefinite number of books, etc. . . . Coverage of articles estimated to be perhaps 15 per cent of world's total engineering literature." EI estimates that 50,000 references/yr. would provide reasonable coverage, which if undertaken on the basis of expanding present EI activities, would increase its operating costs by 50 per cent.

At NSF's Conference the 14 participating Services formed a National Federation of Science Abstracting & Indexing Services. An interim executive committee of G. M. Conrad of Biological Abstracts, D. B. Baker of CA, and J. C. Green of TIC, Dept. of Commerce, was appointed. Each Service will name a representative to a temporary Council to serve until formal organization takes place. The Federation's objective is "to improve the documentation (abstracting, indexing, and analyzing) of the scientific and technological literature of the world in such a manner as to make it readily available to all scientists and technologists."

In recent (June 25-26) testimony before the Subcommittee on Organization of the Senate's Committee on Government Operations, NSF's director Allan T. Waterman, with Burton W. Adkinson, head of NSF's Office of Scientific Information, spelled out the principal difficulties being faced in rapidly expanding translation activities.

"During and since World War II," stated Waterman, "because of the vastly greater funds poured into scientific research and the greater activity there . . . a flood of information has swamped the conventional facilities for publishing and disseminating technical knowledge and has brought demands for speedier and more efficient research finding, for better research knowledge, and for better bibliographic services. . . . With the vastly greater quantities of scientific information to be processed and controlled, and the accompanying increase in complexity of systems, conventional techniques for storing and treating data have become inadequate.

"At present, the Foundation is actively engaged in recruiting a staff and developing a program to meet this need for an organization that, on a nationwide basis, will be able to identify and analyze the strengths and weaknesses in existing practices and then to take aggressive action, both to develop solutions and to take pre-

continued on page 17

Space Travel is Goal of New Industrial Combine

The chemical and automotive industries have joined hands in a working agreement "aimed at developing advanced devices in the field of guided missiles and space travel": partners in the agreement are General Motors, Callery Chemical, and Thiokol Chemical. General Motors will provide the talent for air breathing engines, guidance systems, missile components, and structures; Callery will provide propellant components for space vehicles; Thiokol will add its capabilities in solid and liquid fueled rocket propulsion systems.

SCOPE

African Alumina to be International Venture

Based on vast bauxite deposits in French Guinea, a new alumina project expected to cost $135 million will be developed by a syndicate composed of five corporations from four Free World nations. Initial capacity will be 480,000 tons a year of alumina, projected expansion to 1,200,000 tons a year is expected to make the plant the largest in the world.

Official name of the new company is FRIA Compagnie Internationale pour la Production de l'Alumine: participating companies are Olin Mathieson Chemical Corp., which will own 53½% of the equity; two French companies, Pechiney and Ugine (26½%); Aluminum Industrie Aktiengesellschaft, Zurich, Switzerland (10%), and British Aluminium Co. (10%). Share holders in FRIA will have the right to purchase alumina from the company in proportion to their respective percentages of ownership.

The Guinea bauxite deposits have been prospected by Pechiney since 1942 and since 1951 by SAREPA (the African Society for the Discovery and Study of Aluminum, jointly established by Pechiney and Ugine). Proved resources are more than 200 million tons, 1.5 billion tons are said to be indicated in other areas of French Guinea. The process to be used has been developed and tested by Pechiney which will construct and operate the plant.

Location of the plant will be in the Badi-Konkoure region, about 80 miles from Conakry on the African coast. Auxiliary facilities will of necessity be extensive. A railroad will be built from the plant site to Conakry to transport raw materials to the plant, and to carry the product alumina to the coast for shipment. At Conakry, FRIA will install silos, warehouses, loading and unloading equipment, doubling the capacity of the harbor. A new town of some 4,000 people will rise on the plant site to house workers at the bauxite mines and at the alumina plant.

Equity contributions from the participating companies total $39 million. $96 million will be raised by loan funds from U.S. institutional investors, FRIA obligations sold to the French public, loans form British Aluminium and Aluminum Industrie Aktiengesellschaft (Swiss), and a long-term French government loan. Olin Mathieson is negotiating with the International Cooperation Administration for a U.S. Government guarantee covering both its equity contribution to the project and the loan funds from U.S. institutional investors.

United Engineering Center Building Fund

Member Gifts Campaign	Total No.	Subs. to Date Amount
ASCE	458	$83,762.42
AIME	83	74,983.75
ASME	501	61,556.40
AIEE	961	70,967.44
A.I.Ch.E.	198	74,590.54
Other	40	18,300.83
Total Member Gifts	2,241	384,161.38
Industry Campaign		
National	145	3,441,883.00
Greater New York	15	82,700.00
Total Industry Gifts	160	3,524,583.00
Total Subscriptions	2,401	$3,908,744.38

From Here and There

Largest fuel order in the history of commercial aviation has been awarded by American Airlines to nine U. S. oil firms: contracts could provide for as much as 4 billion gallons of jet fuel over the next 10 years. . . . *Electricity from heat*—newest thermionic converter, made in G. E.'s Schenectady laboratories, is a combination of metal and ceramic discs about the size of a quarter. . . . *Molybdenum hexacarbonyl*, tungsten hexacarbonyl, and tungsten hexachloride are now available in semiworks quantities from Climax Molybdenum. . . . *"The world is better off because of science"* said 83% of persons interviewed in a nationwide poll conducted by the National Association of Science Writers. . . . *Two new foreign developments* in the chemical industry: Dow Agrochemicals Ltd. has been formed for the manufacture and sale of agricultural chemicals in Great Britain; United States Rubber and Rumianca, of Turin, Italy, will form a new Italian company to make and sell in Italy a line of chemical products developed by U. S. Rubber's Naugatuck Chemical Division. . . . *"Big business needs scientists* today in almost every department," said recently Sir Alexander Fleck, chairman of Britain's Imperial Chemical Industries, speaking before the British Association for the Advancement of Science. . . . *Chinese Petroleum Corp. has awarded* Badger Manufacturing a contract for design, engineering, and equipment supply of a sulfuric acid alkylation plant for Formosa. . . . *Eastman Kodak has announced* pilot-plant production of a "new type" of polypropylene, developed in the research laboratories of Tennessee Eastman, at Kingsport, Tenn.

Packaged Liquid Rocket Engines—First Military Use

A Navy contract has been awarded to Reaction Motors Division, Thiokol Chemical for production of package liquid rocket engines. Designated as the Guardian, the engine will be supplied in a fully operative condition, complete with propellants loaded at the factory.

SCOPE

Increased Demand for Technicians Seen

"Technicians who work with engineers and scientists are one of the fastest growing occupational groups in the United States," said the Labor Department recently, announcing a new study prepared by the Bureau of Labor Statistics in cooperation with the Veterans Administration.

Many more thousands of technicians will be required over the next decade to meet the needs of the Nation's defense program and to make possible continued expansion and technological advances in the civilian economy, according to the Department. "These workers, whose jobs require basic scientific and mathematical knowledge as well as manual skill, are making an ever more important contribution to our country's defensive strength and industrial growth," says the report.

Chemical and allied industries are today one of the leading groups in the employment of technicians in research and development, with a total of 8,400 in 1954. This compared with 18,500 for the electrical equipment industry and 17,200 for the aircraft industry, the two largest employers. Most of these research and development workers (about 85%) were employed by the larger companies—those employing 5,000 or more workers.

According to a survey of 309 plants, average straight-time hourly earnings of technicians in the chemical industry was $2.10 (figures are for late 1955). Hourly wages varied from $2.27 in Charleston, West Virginia, down to $1.83 in Detroit, Mich.

The Federal Government is also an important employer of technicians. As of February, 1957, it had 31,099 employees in the selected technician category. About 60% of these were working in the Department of Defense—in the Army, Navy, and Air Force.

There are several routes by which young men can prepare for such positions. These include technical institutes, junior and community colleges, extension divisions of universities, and colleges offering 2-year technical programs. Training for technician jobs can also be obtained through programs operated by companies for their employees, and from correspondence schools, vocational schools, and a few advanced technical high schools. Many workers, however, become technicians through on-the-job training and experience only.

Further details are given in report (VA Pamphlet 22-1) available from the Veterans Administration, Washington 25, D.C.

Translations

from page 15

ventive measures against unforeseen future problems . . .

Adkinson explained NSF's operation in the field of translation as: "At the present time we make grants to professional organizations and universities to do this job, and they work with commercial organizations who have their own translators."

As to stepping up NSF's translation program, Adkinson said: "It isn't a case of finances at the present . . . It is difficult to get people to work full time translating who have the subject competence in science or engineering because they want to keep their hands in their regular technical work . . . There is not a lack of translators; [it is a matter of] finding people with experience in the subject field who have language [qualifications]; and who can translate, and getting them into a working group to process a journal."

In a letter to the chief clerk and staff director of the Senate Committee, which appears in the official Subcommittee report, Ralph H. Phelps, director of the Engineering Societies Library, comments: "... the abstract-

continued on page 18

Nitrogen Tetroxide in Pilot Plant Quantities

Construction of a pilot plant for production of nitrogen tetroxide will begin immediately, initial quantities will be available in 3 or 4 months. The oxidizer, which shows promise for liquid-fueled rockets and missiles, will be made in Hercules, Calif. by Hercules Powder, will use a new Hercules-developed process.

Largest Foreign Investment Guarantee Contract

Convertibility into dollars of up to $17,750,000 from private investment sources in the U. S. has been assured by the International Cooperation Administration for a new chemical fertilizer plant to be erected and operated in Trinidad by W. R. Grace & Co. A new company, Federation Chemicals Ltd., in which British capital will also be involved, will produce chemical fertilizers and allied products for sale in the Caribbean area, South America, and other parts of the world. Main source of raw materials will be hydrocarbons from natural gas supplies presently lost through the flaring operations of the Trinidad refineries.

U.S. Polypropylene To Be Upped by 40 Million lb./year

Newest entry in the plastics field is Humble Oil & Refining which will build a 40 million lb./yr. polypropylene plant in Baytown, Texas, aimed at early 1960 start-up. Almost simultaneously, Reeves Brothers, New York textile manufacturer, has begun commercial production of polypropylene yarn, expected to find application in chemical processing for wet and dry filter elements, other uses now filled by Nylon, Saran, and polyethylene fibers. Reeves' source of polyethylene is not disclosed, but is probably Hercules Powder, believed to be only present U. S. producer.

SCOPE

Government R&D Revamp Urged

Defense Department research and development programs should be completely overhauled, administrative channels dredged out, and contract procedures streamlined—says a recent report of the House Government Operations Committee. This is now possible, emphasizes the report, under the new Defense Department Reorganization Act, recently signed by President Eisenhower, which provides for a single director of research and engineering, responsible directly to the Secretary of Defense.

Research and development contracts, by their very nature, cannot be handled in the same way as ordinary procurement operations, points out the House Committee. A "year-to-year" basis is not suitable here.

Methods of handling contract cancellations and project cutbacks also came in for severe criticism from the Committee, which claims that last year's 10% cut in research spending, even though later restored after the Russians launched their first satellite, had a crippling effect on the whole research program.

Constructive as well as negative were the conclusions of the House Committee report. Most important recommendation, perhaps, is that control of research and development be integrated in the hands of the new director of research and engineering. It is hoped that this might eliminate some of the confusion occasioned by the fact that, today, three different research divisions report to the Secretary of Defense: The Advanced Research Project Agency; a group headed by the Assistant Secretary of Defense for Research and Engineering; and a group under the Director of Guided Missiles.

Second Committee suggestion: simplified procedures for the evaluation and approval (or disapproval) of proposed research projects. According to the Committee, long delays in acting on proposals not only slow down the projects themselves, but can have a disastrous effect on the morale of the engineers and scientists involved.

Final recommendation of the Committee is that an independent firm of management consultants be called in to make a thorough survey of operations in the office of the Secretary of Defense.

Translations

from page 17

ing services now in existence are not as bad as they are made out to be . . .

"If the Soviets," Phelps continues, "have profited more than we have from the technical literature, I would believe that they may have worked harder at using it. The Soviet centralized information services are not essentially better than the services available in this country; Soviet abstract services are in general poorly indexed compared to ours, and so are therefore difficult to use. . . .

"I know from experience that all too seldom is any substantial literature search made. . . .

"I would suggest that the Government should, probably through the NSF, give assistance in the support of projects such as some being considered by the National Federation of Science Abstracting and Indexing Services, which should help to improve existing . . . services. I do not believe that a large Government operation [such as proposed in Senate bill 3126] in the field of documentation is either necessary or economically desirable. Organizations which provide a useful information service will be supported in the typical American way by those who find the services useful."

Washington Notes

Underground nuclear explosions are being investigated by AEC as a possible source of radioisotopes: location of tests may be in the salt bed area, about 25 miles southeast of Carlsbad, New Mexico. . . . *Look for public announcement* shortly of a new Navy-developed weapons system, the "Eagle," said to combine planes, missiles, guidance system. . . . *Manufacturers who export products* wholly or partly made from imported raw materials will benefit from the President's recent signing of Bill H.R. 9919 which amends the Tariff Act of 1930 to provide for recovery of 99% of the duty paid on imported raw materials used in production of items exported within three years. . . . *The Government is seeking* an effective and economical method of protecting its open-air stockpiles of strategic materials such as bauxite, other ores containing strategic alloying elements. Any and all suggestions will be welcomed. . . . *Economic trend spotters in Washington are concerned* about the effect of the European Economic Community on our export trade. Most effective remedy is considered to be the establishment by American companies of branch plants within the ECC countries.

—J. L. Gillman, Jr.

British Anticipate Large Slice of Russian Pie

Britain expects to get orders from Russia for about $200 million worth of large-scale chemical production plants. The *Financial Times* of London estimates at $784 million the total which the Russians intend to spend in the near future for foreign purchases in this field.

Nitrile Silicone Rubber Resists High Temperature, Oil

A combination of properties "never before available in a single material" is claimed by General Electric for its new nitrile silicone rubber. Resistance to oil, strength retention at more than 500°F., maintenance of characteristics at minus 100°F., are expected to lead to wide use in aircraft, automobiles, process equipment. Price will be about $15/lb., commercial production is slated for late 1958.

ADVERTISEMENT—*This entire page is a paid advertisement* *Prepared by U. S. Industrial Chemicals Co.*

U.S.I. CHEMICAL NEWS

Sept. ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1958

Aliphatic Dinitriles And Diamines Prepared From ISOSEBACIC® *Acid*

A new method of synthesizing aliphatic dinitriles and diamines — some of them believed to be new compositions of matter — is described in U.S. Patent 2,824,118, recently issued to U.S.I.

ISOSEBACIC acid is reacted with ammonia and/or urea or other nitrogen-containing compounds to form a mixture of C_{10} dinitriles. They are primarily sebaconitrile, α-ethylsubero-nitrile and α,α′-diethyladiponitrile.

The nitrile mixture can then be hydrogenated in the presence of ammonia and a catalyst to yield C_{10} diamines. They are a mixture of decamethylene diamine, 1,8-diamino-2-ethyloctane and 1,6-diamino-2,5-diethylhexane.

The dinitriles are considered valuable as chemical intermediates, and for solvents, lubricants, plasticizers and textile water repellants. The diamines should be useful in the synthesis of various types of polyamides — particularly fibers — and in plastics, rubbers, plasticizers, synthetic lubricants, polyurethanes and other products.

Nutritional Dystrophy Studies Show Lower Methionine in Blood

It has been reported that determinations of methionine in the blood of children with nutritional dystrophy average considerably below normal. In a study of whole blood from malnourished and normal boys, methionine content was found to average 73 mg. lower in the first group (331 ± 16 mg. as against 404 ± 16 mg. for the normal group). Determinations on the serum alone did not reveal a similar variation.

It was felt by the investigators that low values in the whole blood of the malnourished children might be due to hypochromic anemia prevalent in the group.

390 Million Nonfood Aerosols Sold in 1957

The Chemical Specialties Manufacturers Association estimates that 390 million nonfood aerosol units were produced in 1957, based on 339 million units reported in their survey and adjusted for companies not responding. Here's how the report looked, in millions of units:

Hair Sprays	94.4
Shaving Lather	50.9
Room Deodorants	41.9
Insect Sprays	41.5
Coatings	36.5
Colognes and Perfumes	17.9
Household Products Other Than Room Deodorants and Glass Cleaners	16.9
Personal Products Other Than Shaves, Hair Sprays, Colognes & Perfumes	12.3
Glass Cleaners	11.2
Miscellaneous	15.6

New Roles Seen for Ethanol in Medical & Pharmaceutical Fields

Recent Developments Include New Nerve Block Application, And Improvement of Ruminant Nutrition

Medical and biochemical research on ethyl alcohol — best known as a solvent — is constantly revealing new facets of its personality. It is evident that ethanol has *many* modes of action—physical, chemical and biological — that are important to the doctor, the nutritionist and the producer of pharmaceuticals.

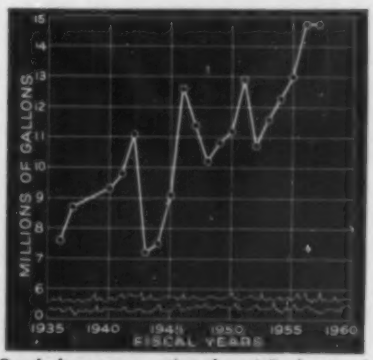
The practical use of ethanol in medicine as a nerve block agent is increasing. A few months ago a team of radiologists and neurosurgeons revealed a method of treating the painful facial *tic douloureux* by radiologically controlled injections of absolute alcohol. Forty-five patients so treated experienced immediate relief of symptoms, it was reported, although several had to be retreated, and one finally had to undergo the usual surgery.

New Function in Microbiology

Fermentation processes utilize several of ethanol's well-known modes of action—solvent, carbon source for yeast growth, and nutrient raw material for bacterial conversion into other chemicals.

And now, within the last year, a patented* novel use of ethanol in fermentation has begun to revolutionize the ruminant feed industry. It has been discovered that alcohol ingestion by cattle and sheep accelerates rumen microflora metabolism, by acting as a hydrogen donor. Ethanol has the unexpected property of maintaining a low oxidation-reduction potential in the rumen. This allows greater utilization of natural feeds rich in cellulose, and enables the micro-organisms in the rumen to make better use of nonprotein nitrogen materials such as urea. The microfloral cycle is

MORE



Graph shows consumption of specially denatured alcohol in pharmaceuticals and toiletries.

Sources: (a) STATISTICS ON THE USES OF SPECIALLY DENATURED ALCOHOL, Internal Revenue Service (data for 1936-1937 and 1940-1957). (b) ANNUAL REPORTS OF THE COMMISSIONER OF INTERNAL REVENUE, Internal Revenue Service (data for 1938 & 1939).

Heterocyclic, Homocyclic Systems Made by New Route

Research chemists have discovered that heterocyclics and homocyclics can be synthesized by an entirely new method. Potassium amide is reacted with the starting material to form a benzyne intermediate with a nucleophilic center. Nucleophilic means "seeking an electron-deficient group." In the presence of liquid ammonia, this center then adds intramolecularly to give a closed-ring compound.

Indane, indole, 2-phenylbenzothiazole, benzoxazole and phenothiazine have all been made by this new technique, and the research group believes it can be used to prepare many other hetero- and homocyclic compounds. Both five- and six-membered rings have been formed, all through intramolecular addition of nucleophilic sulfur, oxygen, nitrogen and carbon.

Stauffer's $TiCl_4$ Plant Bought by Mallory-Sharon

Stauffer Chemical Company's new 50 million pound-per-year titanium tetrachloride plant at Ashtabula, Ohio has been purchased by Mallory-Sharon Metals Corporation, which in turn is one-third owned by U.S.I. The new acquisition completes the company's integration of facilities for producing titanium — from ore to finished mill products.

New Method for Making Glycidyl Esters

The glycidyl esters — important as perfume and flavor ingredients, and in vinyl plasticizers, stabilizers and resin intermediates — can now be synthesized by using sodium hydride in oil as the condensation reagent in the Darzen condensation reaction.

When employed together with a ketone and a chloroacetate acid ester, NaH in oil is reported to give excellent yields in short reaction times at room temperature, with little or no side reaction.

NaH in oil is a 50% dispersion of 2-25 micron particle size crystals in an inert white mineral oil. It is handled as a solid which can be fed directly into reaction vessels either mechanically or by hand.

NaH in oil is prepared from dispersed sodium and hydrogen at 190-225°C. Its preparation is described in U.S.I.'s brochure "Sodium Dispersions," available on request.

Sept. ★ **U.S.I. CHEMICAL NEWS** ★ 1958

CONTINUED *Ethanol*

accelerated, thus increasing the daily rate of protein synthesis and cellulose digestion.

It is thought that this new role for ethanol may find application in other fermentation processes allied with the manufacture of pharmaceuticals and biologicals.

Ethanol Is a Surfactant

Ethyl alcohol is being used as an antifoam to relieve pulmonary edema in humans which sometimes occurs immediately after surgery. Under such conditions foaming in the lungs interferes with oxygenation. Inhalation of 95% alcohol vapor modifies the surface tension of the fluid and reduces the amount of foam in the lung. It is reported to produce immediate and dramatic recovery in most medical cases.

Protective Action in Body

Data is continually being compiled on the action of ethanol as a protective agent in the body. Organophosphate compounds, such as chemical warfare nerve gases and some agricultural insecticides, are known to act by inhibiting the formation of serum cholinesterase by the organism. It has recently been discovered, that ethanol protects against this inhibiting action.

Animal experiments have shown that preadministration of ethanol gives considerable protection against radiation sickness.

Role in Body Metabolism

In the human body, moderate doses of ethyl alcohol have been found to exert a protein-sparing action—improving protein storage and growth. And it has been reported that a positive nitrogen balance is more easily maintained in human convalescence when glucose and amino acids are supplemented with ethanol. Studies on animals show that ethanol also helps mobilize vitamin A from storage depots in the body.

The roles of ethyl alcohol as a vasodilator, as a stimulant, and as an antiseptic and disinfectant are well known, but should be mentioned here to round out the perspective on this U.S.I.-produced compound — one of the most versatile and valuable chemicals the medical and pharmaceutical fields have at their disposal today.

**U.S. Patent 2,808,332 — Anderson and Rapp*

U.S.I. Tank Car Domes Now Color-Coded for Product

The entire U.S.I. fleet of 900 tank cars is being repainted black on light gray, with the traditional U.S.I. oval in black and red. Inherent in the new design is a color-coding system that immediately identifies the type of service for which tank cars are used. Domes of the tank cars are painted any of the following identifying colors:

Solid Domes
- General Service (alcohol, etc.) ..... White
- Ethyl Ether ..... Light Blue
- Chlorine ..... Light Green
- Ammonia ..... Bright Yellow
- Sulphuric Acid ..... Black
- Phosphatic Fertilizer Solution ..... Bright Orange
- Nitrogen Fertilizer Solution .... Bright Red
- Caustic Soda Cars ..... Maroon
- Metallic Sodium ..... Gray

Black Domes with 4 Inch Color Stripes
- Ethyl Chloride ..... Black with Orange
- Olefin ..... Black with Yellow
- Miscellaneous gasoline, waste material ..... Black with Red

This new color-coding system provides U.S.I. with a double check — an at-a-glance opportunity to pick up errors before cars reach the loading rack.

Black, light gray and color-coded dome combine to give new look to U.S.I. tank car fleet. Overall design was chosen to give company identity, dome color to give product identity. Here a newly painted U.S.I. Alcohol tank car with identifying white dome is loaded at Tuscola, Ill.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

N-meta-tolyl phthalamic acid has been discovered to increase plant yields by reducing shock and stress of heat, cold, long rains and drought. Material has been test-sprayed on limas, cotton, cherry trees. **No. 1390**

New booklet on polyethylene film, coatings and molded items for packaging field illustrates advantages of material in terms of economy, sales appeal, protection of product and convenience. **No. 1391**

Zone-melting purifier for organic compounds now on market. Claimed to permit preparation of hyperpure solids in laboratory through slow travel of ring heater up along glass tube containing solid. Impurities concentrate at top. **No. 1392**

New insect repellent, diethyltoluamide, is said to be most effective ever developed for mosquitos, fleas, ticks, chiggers, deer flies. Product now being made with 95% minimum meta isomer content. **No. 1393**

Rare books on science and medicine which can be purchased are listed in new catalog which includes 258 works, alphabetically by author. Catalog covers only a portion of books available. Lists works printed from 1495 to 1929. **No. 1394**

A new aluminum hydroxide-magnesium carbonate co-precipitate dried gel is being sold which, it is claimed, will permit antacid producers to market tablets and powders with the same therapeutic value as the usual liquids. **No. 1395**

Series of ultrasonic units — mass-produced, low-cost, laboratory-size — has been developed for cleaning small delicate parts or assemblies, glassware, apparatus. Also suggested for biological, medical, chemical studies. **No. 1396**

2-Carbethoxycyclopentanone is now available commercially for pharmaceutical and fine chemical applications. Is precursor for many 2-substituted cyclopentanones. Enters into variety of reactions typical of beto-ketoesters. **No. 1397**

3-Sulfolene and some derivatives can now be obtained in research quantities. It is a controlled source of pure sulfur dioxide. As an intermediate, it reacts with chlorine, water, ammonia, alcohol and mercaptans. **No. 1398**

Odor-metering apparatus and techniques for its application to industrial odor-control problems are described in new 4-page brochure. Odor meter measures subjective impressions, must be operated by experienced personnel. **No. 1399**

PRODUCTS OF U.S.I.

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Proprietary Denatured Alcohol Solvents: SOLOX® — General-purpose. FILMEX® — Special, authorized for certain industries. ANSOL® M — Anhydrous, special blend for lacquers, resins, etc. ANSOL® PR—Anhydrous, special blend with higher ester content and solvency for lacquers, resins, etc.

OTHER PRODUCTS

Organic Solvents and Intermediates: Normal Butyl Alcohol, Amyl Alcohol, Fusel Oil, Ethyl Acetate, Normal Butyl Acetate, Diethyl Carbonate, DIATOL®, Diethyl Oxalate, Ethyl Ether, Acetone, Acetoacetanilide, Acetoacet-Ortho-Chloranilide, Acetoacet-Ortho-Toluidide, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sodium Ethylate, ISOSEBACIC® Acid, Sebacic Acid, Urethan U.S.P. (Ethyl Carbamate), Riboflavin U.S.P., Pelargonic Acid, and 2-Ethyl Heptanoic Acid.

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Animal Food Products: Antibiotic Feed Supplements, BHT Products (Antioxidant), Calcium Pantothenate, Choline Chloride, CURBAY B-G®, Special Liquid CURBAY, VACATONE®, Menadione (Vitamin K_3), DL-Methionine, MOREA® Premix, Niacin USP, Riboflavin Products, Special Mixes, U.S.I. Permadry, Vitamin B_{12} Feed Supplements, Vitamin D_3, Vitamin E Products, Vitamin E and BHT Products.

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NICKEL and MONEL* VALVES

Fig. 2108—Monel or Nickel "Y" Valve for 150 pounds W.P. Outside screw rising stem and yoke. Screwed ends. Flanged end or socket welding end valves can be supplied.

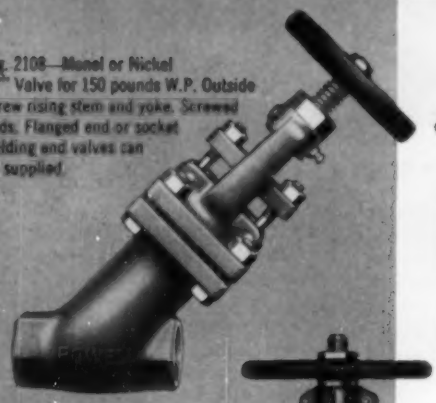

Fig. 2453 SG—Large size O.S. & Y. Gate Valve for 150 pounds W.P. Solid wedge disc. Can also be furnished with split wedge disc. Dimensions conform to latest standards.

Fig. 1836—Monel Metal
Fig. 1839—Nickel
Small Union Bonnet Globe Valve for 200 pounds W.P. Available with screwed, flanged or welding ends; also in angle pattern.

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Fig. 1828—Monel Metal
Fig. 1830—Nickel Inside screw rising stem Gate Valve for 200 pounds W.P. Accurately guided solid wedge disc. Also available with flanged or socket weld ends.

Fig. 1843—Monel Metal. Fig. 1845—Nickel. Small size Check Valve for 200 pounds W.P. Screwed-in cap. Has straightway flow area through valve body when disc is in wide open position. Can also be supplied with flanged or socket weld ends.

Fig. 2493—Bolted flanged bonnet Gate Valve for 150 pounds W.P. Outside screw stem rises through revolving bushing in upper yoke. Interchangeable solid or split wedge discs. Screwed or socket weld end valves also available.

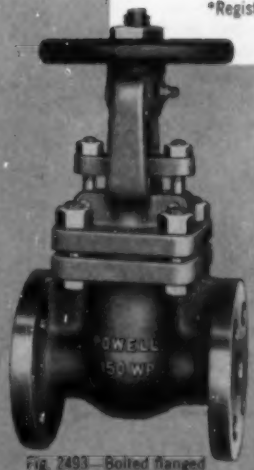
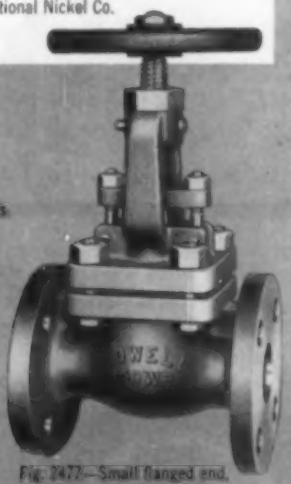


Fig. 2472—Small flanged end, outside screw rising stem and yoke Globe Valve for 150 pounds W.P. Bolted flanged bonnet. Can be furnished with screwed or socket weld ends. Angle Valves available.



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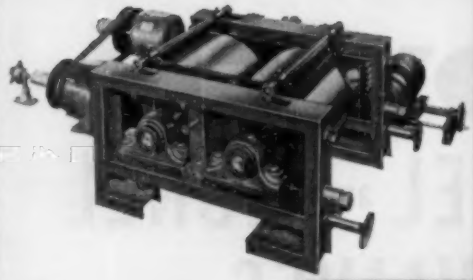

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For rapid and continuous conversion of liquids and slurries to dry solids. G-B atmospheric drum dryers provide an economical and practical means of drying many chemicals.

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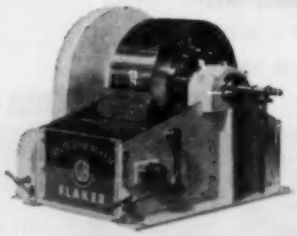
For heat sensitive products and recovery of solvents. G-B vacuum rotary dryers used for removal of moisture from centrifuged or filtered solids at low temperature levels.



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marginal notes

PREPRINTS — 1958 HEAT TRANSFER AND FLUID MECHANICS INSTITUTE. Stanford University Press, $7.50.

Reviewed by Myron Tribus, General Electric Co., Cincinnati, Ohio.

This year the Institute offered twenty-one papers in three days of meetings at the University of California in Berkeley. Two fields of research were selected for emphasis: aerothermodynamics and magnetohydrodynamics. Problems of aerothermodynamics occupy the attention of workers in the fields of combustion and high-speed flows. Magnetohydrodynamics is becoming important in flow of ionized gases, as in the hydrogen fusion reaction.

One of the features was an introductory paper by Howard W. Emmons, who presented the general equations for aerothermodynamics and reduced them for a number of specific cases. He also introduced an original approach to the reacting boundary layer, using integral methods to investigate combustion stability.

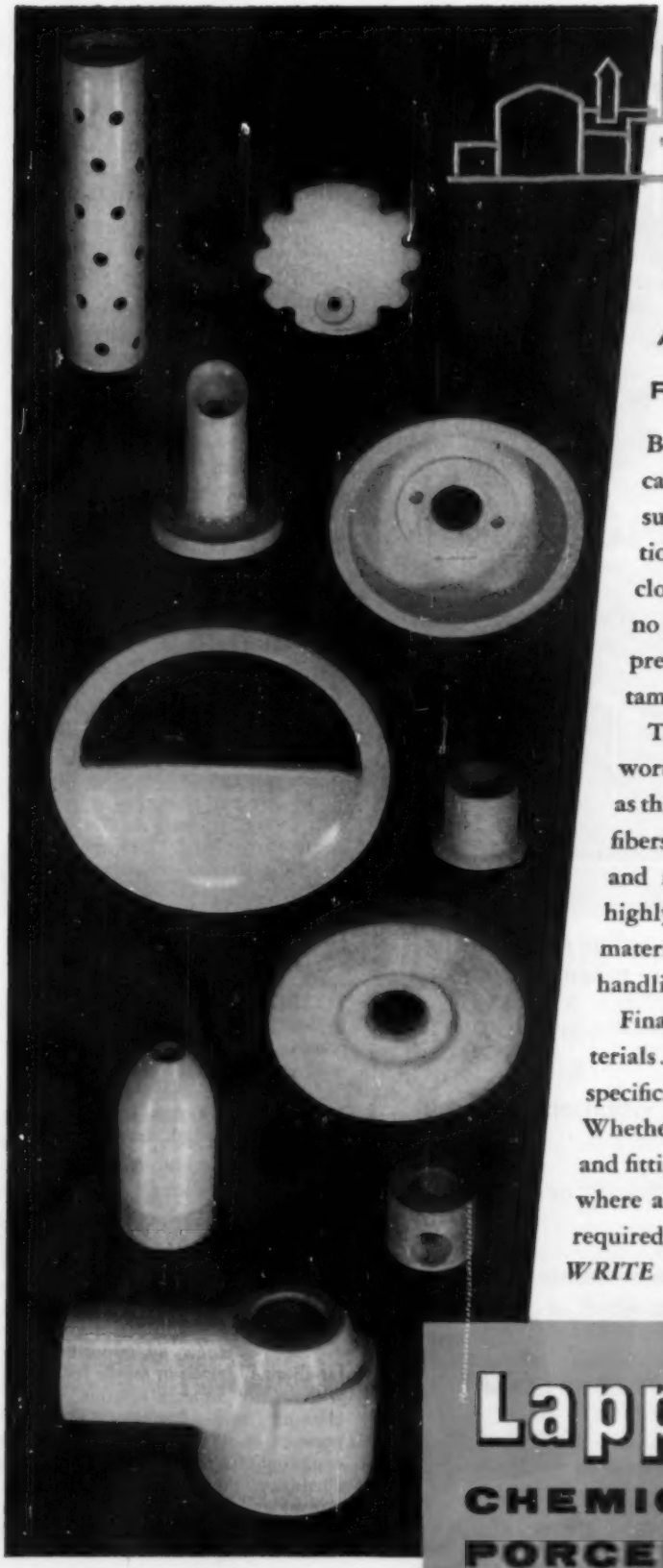
Other papers dealing with aerothermodynamics phenomena are "Mass Transfer Cooling with Combustion in a Laminar Boundary Layer" by J. P. Hartnett and E. R. G. Eckert, "Considerations Related to the Quenching of Flames with Simple Kinetics" by Melvin Gerstein and A. E. Potter, "Wave Propagation in a Reacting Mixture" by Boa-Teh Chu, "Criteria for Thermodynamic Equilibrium in Gas Flow" by M. Rudin. Several other papers in this field are included.

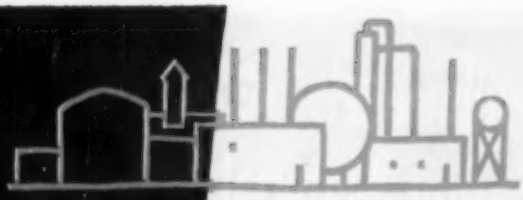
Three general approaches to the problems of magnetohydrodynamics were given: one by Rolf Landshoff, one by S. Lykoudis "On a Class of Magnetic Laminar Boundary Layers," and a third by K. P. Chopra and S. F. Singer, "Drag of a Sphere Moving in a Conducting Fluid in the Presence of a Magnetic Field."

In addition to these specialized papers, there were a number of contributions to supersonic flow and to the understanding of heat transfer and fluid mechanics.

All in all, the 1958 Heat Transfer and Fluid Mechanics Institute managed to retain the high standards that have marked its proceedings in the past. Preprints, available from Stanford, are bound in an attractive binding which differs from previous years in that it is 6¾ by 10 in., therefore, easier to put on one's book shelf.

continued on page 24





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Because Lapp Chemical Porcelain is chemically inert, it is corrosion resistant and ideally suited for handling acids of all concentrations. It is pure, dense, hard, homogeneous, close-grained and non-porous so there can be no penetration—no crumbling from capillary pressures—no absorption of liquids to contaminate later processing.

The hardness of Lapp Porcelain proves its worth when used as a "running surface" such as thread guides or rolls for processing synthetic fibers or sheet stock . . . it cannot be scratched and raise a "burr." Since Lapp Porcelain is highly abrasion resistant, it becomes an excellent material for piping to carry off fly-ash; or for handling cement, pigments and abrasive slurries.

Finally, Lapp Porcelain uses low cost raw materials . . . it can usually be fabricated to customer's specifications for considerable dollar savings. Whether it be special sleeves, nozzles, tubes, pipes and fittings, trays, plates, grates or any other parts where acid and/or abrasion resistant surfaces are required, look to Lapp Chemical Porcelain.

WRITE for description and specifications. Lapp Insulator Co., Inc., Process Equipment Div., 2302 Chestnut St., Le Roy, N. Y.

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marginal notes

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THE CHEMISTRY OF ORGANOMETALLIC COMPOUNDS, E. G. Rochow, D. T. Hurd, and R. N. Lewis. John Wiley & Sons, Inc., New York (1957), vii + 344 pp., $8.50.

Reviewed by Kenneth A. Kobe, University of Texas, Austin, Texas.

Not an exhaustive compendium of compounds, but a discussion of the carbon-metal bond, methods of preparation, reactions, and uses in organic synthesis, this work covers organometallic compounds from cacodyl (1841) to ferrocene (1951) and Ziegler catalysts. A chapter is devoted to each group in the periodic table. Many references are given to the original literature. Necessarily the space devoted to each element must be brief: lead, 8 pp.; mercury, 17; magnesium, 16; silicon, 24, of which 13 are references.

Of particular interest is the chapter on Organometallic Compounds in Organic Synthesis which includes, among other interesting topics, anionic polymerization and a discussion of Ziegler catalysts for olefin polymerization.

The general public is acquainted with tetraethyl lead as the organometallic compound. The chemical engineering student in organic chemistry learns about the Grignard reagent, and then forgets about organometallic compounds until he bumps into them again in many industrial applications.

This book is a good place to start to learn about organometallic compounds in general. The authors will send you on to the original literature.

ION-EXCHANGE RESINS. J. A. Kitchener, Methuen & Co. Ltd., London (1957), 105 pp.

Reviewed by R. L. Moison, Research Project Supervisor Chemical Engineering, Du Pont Company, Wilmington, Delaware.

This worthwhile addition to the Methuen Monograph Series offers the chemical engineer an opportunity to familiarize himself in only a few hours with many aspects of this rapidly growing field. Professor Kitchener presents an interesting account of the evolution of ion exchange as a field of chemistry, methods for the preparation of ion-exchange resins, equilibria and kinetics, types of applications and recent developments.

continued on page 26

GLYCIDYL ESTER SYNTHESIS NEWS

MHI SODIUM HYDRIDE IN OIL offers new advantages as a reagent for the Darzen's condensation

$$\frac{\text{NaH}}{\text{in oil}} + \frac{R_1}{R_2}\!>\!C{=}O + ClCH_2COOR \rightarrow \frac{R_1}{R_2}\!>\!C\!<\!\frac{O}{}\!>\!CHCOOR + NaCl + H_2$$

The glycidyl esters, now useful as perfume and flavor ingredients, hold promise of a bright future in vinyl plasticizers and stabilizers, and in resin intermediates. Synthesis of these esters, through Darzen's condensation, now can be simplified with better yields obtained in shorter reaction times at room temperature, with little or no side reaction. The key to this advancement is *MHI sodium hydride in oil* which is used as the condensation reagent, together with a ketone and a chloroacetate acid ester. While other bases for this reaction, such as Na, NaOR, and $NaNH_2$, have been used and reported, (1), (2), the *MHI sodium hydride in oil* technique is the newest and most interesting development to date.

MHI research indicates that many ketones can be successfully condensed with NaH in oil and ethyl chloroacetate. A few are: acetone, acetophonone, cyclohexanone, mesityl oxide, methyl isobutyl ketone.

Handled as a solid, MHI NaH in Oil is a 50% dispersion of 2-25 micron particle size crystals in an inert white mineral oil. It can be mechanically or hand fed directly into reaction vessels. Highly reactive, safe to handle, convenient to use, MHI NaH in Oil also has profitable application as a condensing agent for Claisen, Dieckmann, Stobbe, nitrile and related ester condensations and alkylations.

REFERENCES: 1. Newman, M. S. & Magerlein, B. J.; Organic Reactions V pp. 413-429 Wiley & Son (1947)
2. Ballester, M. Chemical Reviews 55, pp. 283-299 (1955)

For complete information concerning MHI NaH in Oil or for samples of this useful industrial chemical, write:

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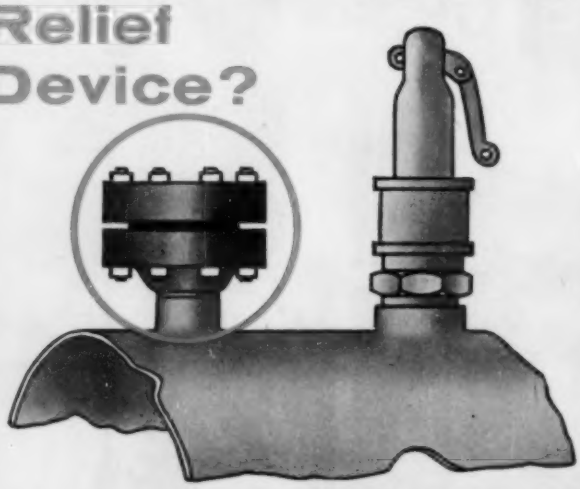
Why The "Standby" Relief Device?



The BS&B *Safety Head* Takes Over Under Abnormal Conditions

Your relief valve may need a helping hand.
The double protection provided by this relief valve–BS&B Safety Head combination is ideal when—

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marginal notes

from page 24

In the opinion of this reviewer, the intelligent use of any of the available methods for designing ion-exchange equipment (e. g., references 1 to 5) requires an understanding of the physical-chemical principles that govern the behavior of ion-exchange resins. Thus, although this book is directed at chemists, much of the material presented, particularly the chapters on equilibria and kinetics, should be quite useful to engineers concerned with the design of ion-exchange equipment.

References cited

1. Baddour, R. F. and E. R. Gilliland, *Ind. Eng. Chem. 45*, 330 (1953).
2. Hiester, N. K., R. L. Nelson, S. B. Radding, and T. Vermeulen, *A.I. Ch.E. Journal, 2*, 404 (1956).
3. Michaels, A. S., *Ind Eng. Chem., 44*, 1922 (1952).
4. Moison, R. L. and H. A. O'Hern, Jr. Paper presented at Baltimore A.I.Ch.E. meeting (September, 1957).
5. Selke, W. A., in "Ion Exchange Technology," edited by F. C. Nachod and J. Schubert, Chapter 4, pp. 52-94, Academic Press, New York (1956).

RADIOISOTOPES — A NEW TOOL FOR INDUSTRY, Sidney Jefferson, Leader of the Technological Irradiation Group, Isotope Division, Atomic Energy Research Establishment of the United Kingdom, Harwell, England. Philosophical Library, Inc., New York (1958), 110 pp., 44 figures.

Reviewed by Joseph J. Martin, Professor Chemical Engineering, University of Michigan, Ann Arbor, Michigan.

This small book is written for the benefit of the layman who is interested in radiation and nuclear energy. However, the author has touched on much more than radioisotopes. One finds herein a brief treatment of nuclear fission, atomic structure, cyclotrons, linear accelerators, and cloud chambers, along with interesting applications of radioisotopes.

Because of the exceedingly broad range of material covered, it is clear that no one topic can be treated in detail. This is not a drawback, however, for the nontechnical person wants only a survey of the field with the principal applications highlighted. It is the practical utilization of isotopes that is emphasized throughout

continued on page 30

HUGE METHANE COLUMN

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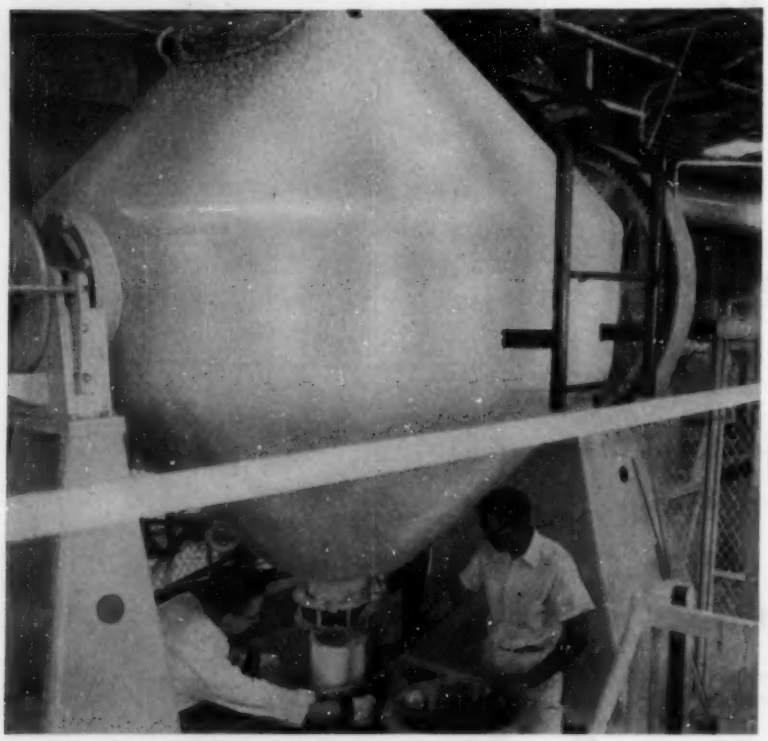
PFAUDLER CORROSIONEERING NEWS



Now Upjohn saves 32 hours drying 2500 pounds of Orinase

Sixteen hours are all it takes for the Upjohn Company to dry and blend 2500 pounds of Orinase in the Pfaudler conical dryer-blender.

It used to take forty-eight hours to dry that much of Upjohn's oral antidiabetic in two straight vacuum dryers.

Upjohn says it also saves eight hours a week in materials handling time with the new dryer.

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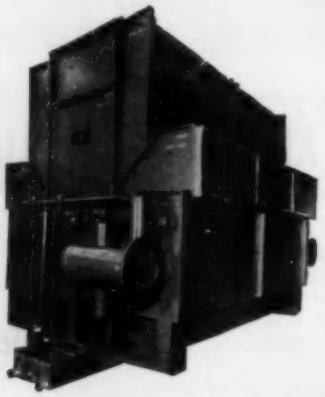

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marginal notes

from page 26

the book, so that the reader comes away with some idea of how not only leaks may be detected, but liquid levels may be measured, thicknesses of materials determined, static charges dissipated, and a number of other operations conducted which are not easy to do by other means.

Jefferson's work is recommended for the executive, the businessman, or the conventional engineer who has no training in the nuclear field. The book is easy to read, is informative, and rather entertaining. For those with a nuclear science or engineering background the book has little to offer.

THERMAL PROPERTIES OF CERAMICS, E. J. Smoke and J. H. Koenig. Engineering Research Bulletin No. 40. College of Engineering, New Brunswick, N. J. (1958), 53 pp., 75 cents.

This report from the New Jersey Ceramic Research Station of Rutgers Bureau of Engineering Research, describes the findings in some phases of the extensive research in ceramic dielectrics which has been carried out there over the past twelve years.

Two other Research bulletins are available gratis. They are "Services Available to Industry in New Jersey (No. 38), and "Lattice Inhomogeneities and Substructures in Crystalline Materials" (No. 39), the first written by Ruth B. Ahrens and R. K. Bogardus, and the second by Sigmund Weissmann.

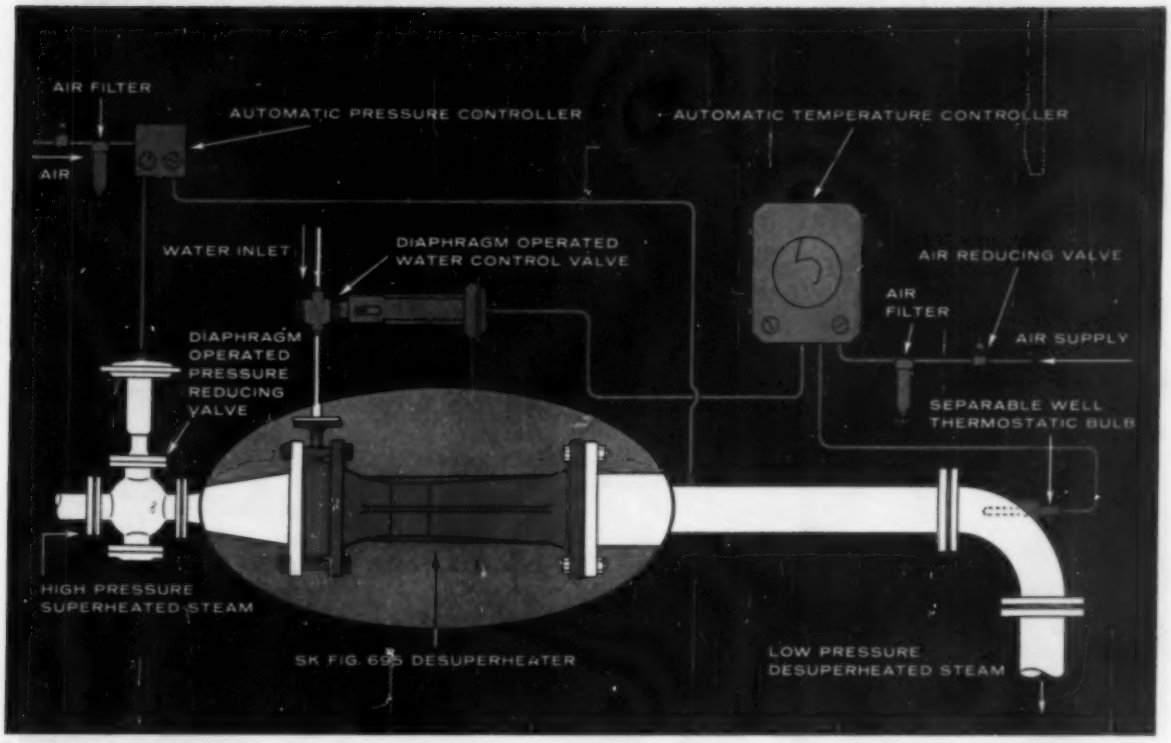
POWER REACTORS. ASME Nuclear Reactor Plant Data Committee, New York, $3.00.

Complete engineering data on eighteen power reactors in the United States are included in this work. Copies can be secured from American Society of Mechanical Engineers, 29 West 39 Street, New York.

This same committee is also assembling similar data on some fifty research reactors throughout the world. This work will be available in early 1959.

Chemicals in Europe

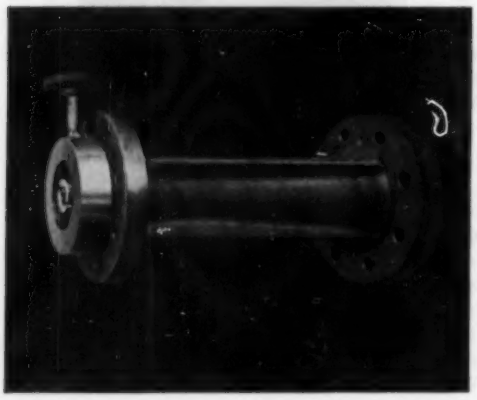
The June issue of "Canadian Journal of Chemical Engineering," giving the papers on the 'Chemical Industry in Europe Today' symposium, is now available. Copies of the issue are available at $1.00 each, and it may be obtained from The Chemical Institute of Canada, 18 Rideau Street, Ottawa, Ontario, Canada.



Reduce Steam Temperature for Process Operations

with this light, easily-controlled Desuperheater

SK Fig. 695 Venturi Type Desuperheater. An important feature of this desuperheater is the fact that the water need not be at higher pressure than the steam entering the desuperheater. As noted in description, right, water can enter the unit at inlet steam pressure.



The SK Venturi Type Desuperheater, shown in the illustrations above and at left, is designed to reduce the temperature of superheated steam to the lower temperatures required for use in process operations and for operating plant auxiliaries.

These Desuperheaters are light in weight and small in dimensions—are supported directly by the superheated steam line. In addition, they are simple in construction, provide straight-through flow with only a small pressure drop. Because these units are designed for application with automatic control, they are particularly well suited for process and petroleum plants where steam flow varies. They can, however, be used without controls where steam flow is steady. In such cases only a separator need be added.

The Venturi Type Desuperheater reduces steam temperature by bringing water into contact with the superheated steam. The water pressure is low since it need only equal the operating steam pressure. The water is preheated in the chamber around the water diffuser and issues, through many small jets, into the steam stream. Since the steam-water mixture is discharged through the desuperheater outlet in a fog-like condition, without contacting the sidewalls, maximum desuperheating effectiveness is obtained and minimum wear occurs in the discharge piping.

The particular desuperheater shown is one of four types made by SK for process plants. Complete details on all types are contained in Bulletin 6D. Write for a copy.

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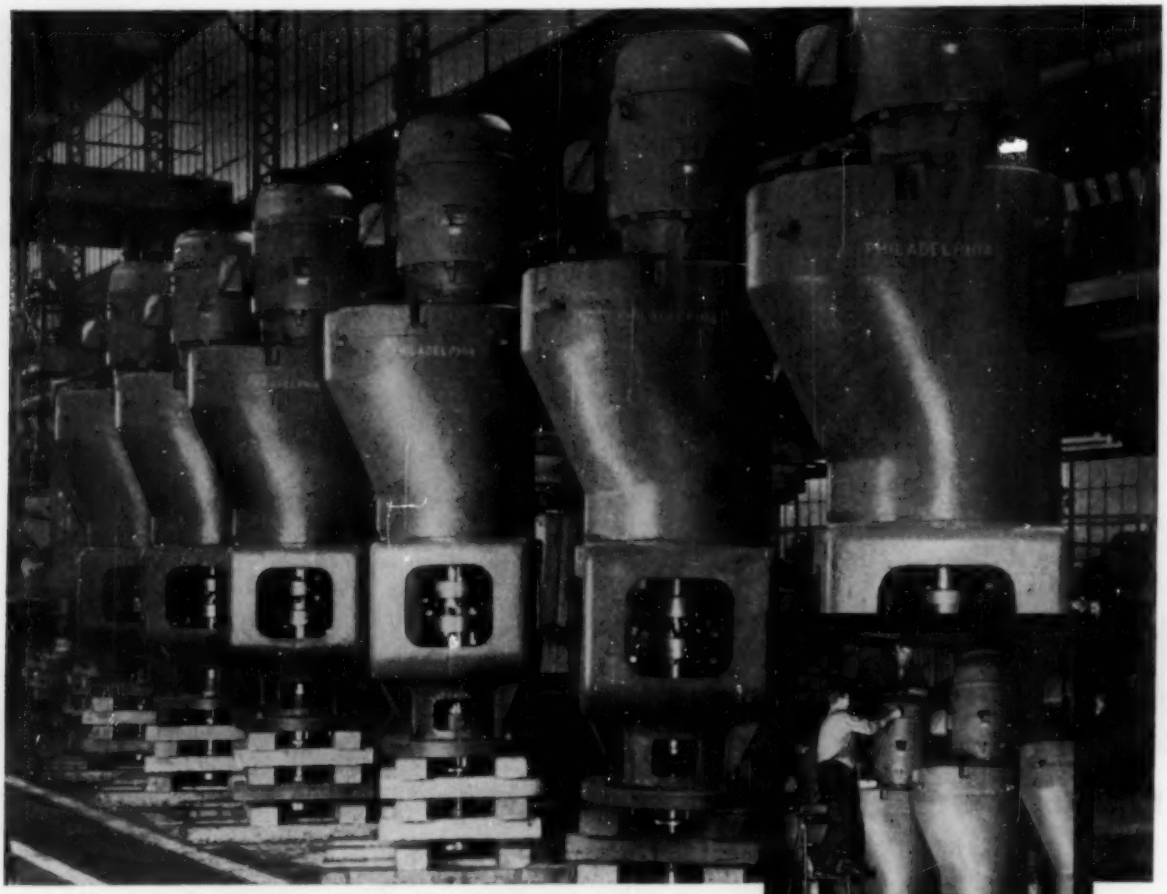

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CEP.....trends

Upswing gains momentum

Business patterns in the third quarter of the year are developing even better than expected. Sales in July, which was the month over which chemical firms were apprehensive because of expected plant vacation shutdowns, held up about as well as in June, a pleasant surprise. August sales continued the expected upturn over July, with sales for some chemical products running from 5% to 15% over the June and July rates. The upturn is expected to continue to gain impetus in September, as motor operations and steel production continue to rise.

All of this means another gain in the earnings of the chemical companies in the third quarter, following the upturn in the June quarter over the low point reached in the first months of the year.

Results of chemical company operations in the second quarter varied considerably, with a few firms showing gains of as much as 20% over profits in the March quarter. Others showed only nominal improvement, but virtually all are looking to a nice lift in the current three months. One exception is Dupont, which, while admitting that business has turned, looks for third quarter earnings at about the same level as in the second quarter. However, earlier the management stated that it hoped sales for the full year would be down not more than 5% from 1957, or not too far from the 1956 level.

Meanwhile, the various business indexes and straws in the wind continue favorable. Perhaps the most outstanding factor is the way that personal income holds up, bolstering the idea that this time personal income, instead of following other economic figures down, is the bulwark that will support the whole business picture. Personal income in July, seasonably adjusted, was at an annual rate of $358.9 billion against $351.8 billion in June and about $351 billion a year ago when business was around the best levels. This would indicate that the recession was caused not by lack of purchasing power but by lack of desire to buy, perhaps caused by consumer feeling that prices were too high. It also suggests the possibility that real recovery, when it comes, may eventually be sharp. A very encouraging piece of news is the rise in private home building starts to an annual of 1,160,000 in July, a contraseasonal rise over the 1,090,000 rate of starts in June and the highest level since January, 1956. Incidentally, stiffening money rates do not seem to be a factor here. The importance of this in its effects on all types of business from textiles to chemicals cannot be overstressed. Another encouraging indication is record production of electricity during the first week in August caused partly by increased numbers and increased use of air conditioning units. Paper board sales, always an important index, are up sharply over a year ago. Steel operations continue to rise to above 60% of capacity, despite the price increases. The rise in operations is expected to continue over the year as motor production increases on new models. The copper industry, long depressed, now feels better as shown by the fact that Kennecott goes on a six-day basis in September from a five-day per week basis due to improvement in sales and (they hope) in the outlook. Finally, the Federal Reserve Bank index of industrial production rose to 133 in July from 131 in June (based on the 1947-1949 average).

One comparatively new facet in the economy is the apparent rise in money rates and the collapse of the government bond market and the corporation bond market during the summer. The full significance of this perhaps cannot be fully appraised at this time. The immediate cause of the collapse in government bonds, one of the worst declines in recent years, was excess speculation on extremely small margins. Although stock buyers must have 70% margin, or owe only 30% of the cost of their securities, it was possible for speculators to buy government bonds on 5% margin, or even less, thus owing 95% of the cost of the bond. Thus it was possible to buy $1 million worth of government bonds for $50,000. Theoretically, the odds in making a very large profit on the investment looked glamorous, since to some buying government bonds is like buying money. But what happened was that speculators overreached themselves so that when money rates rose, bonds paying lower rates of interest were less attractive and they collapsed. Losses of 5 to 7 points on bonds were common and heavy losses were taken by speculators whose capital was cleaned out. New industrial bond issues are expected to pay 4¼% interest rate instead of around 4% as of last year. What effect this may have on business recovery remains to be seen. However, it is unlikely that large industries wishing to expand would worry very much whether they paid 4% or 5% for new money, or that individuals wanting to build a home would hesitate over a difference of 1% in interest rates.

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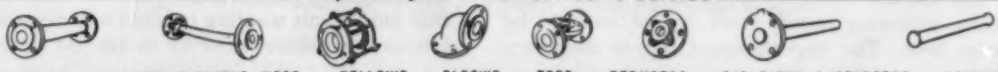

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opinion and comment

your contribution to the future

The new national United Engineering Center is almost a reality. For more than two years, dedicated individuals have gone about the task of bringing together the major elements of engineering society structure in preparation for the historic venture ahead. New cooperative approaches have been developed. The Institute has become a Founder Society, and its entrance into United Engineering Trustees (U.E.T.)—giving it a share in the actual trusteeship of the new Center—has been arranged. Within recent months the beautiful site, directly opposite and facing the United Nations, has been purchased. Architectural and construction engineering teams have been selected. Preliminary plans have developed an imposing 20-story structure.

Besides housing the five Founder Societies, plans call for inclusion of 15 other national engineering groups in the building. The Engineering Societies Library, which contains one of the world's outstanding collection of engineering literature, will be provided with expanded space and modern equipment. Even its mail service to the profession will be enhanced through its new facilities. Ample conference rooms will provide for the needs of society committee functions. Centralized basic services will permit economies and efficiencies through avoiding duplication of efforts and facilities wherever possible.

But wonderful as they may be, the plans of today are no more than plans on paper until adequate funds can be raised to put the construction operation in motion. Thus the need for the Institute, together with the other Founder societies, to engage in a fund-raising drive among its members.

The financial facts are: The total project is now estimated to cost $10 million. Of this, $2 million will come from the U.E.T. $5 million is being contributed by business and industry. This leaves $3 million, to be solicited from the individual society members. The Institute's share of this $3 million fund is $300,000, which is the least of any Founder Society.

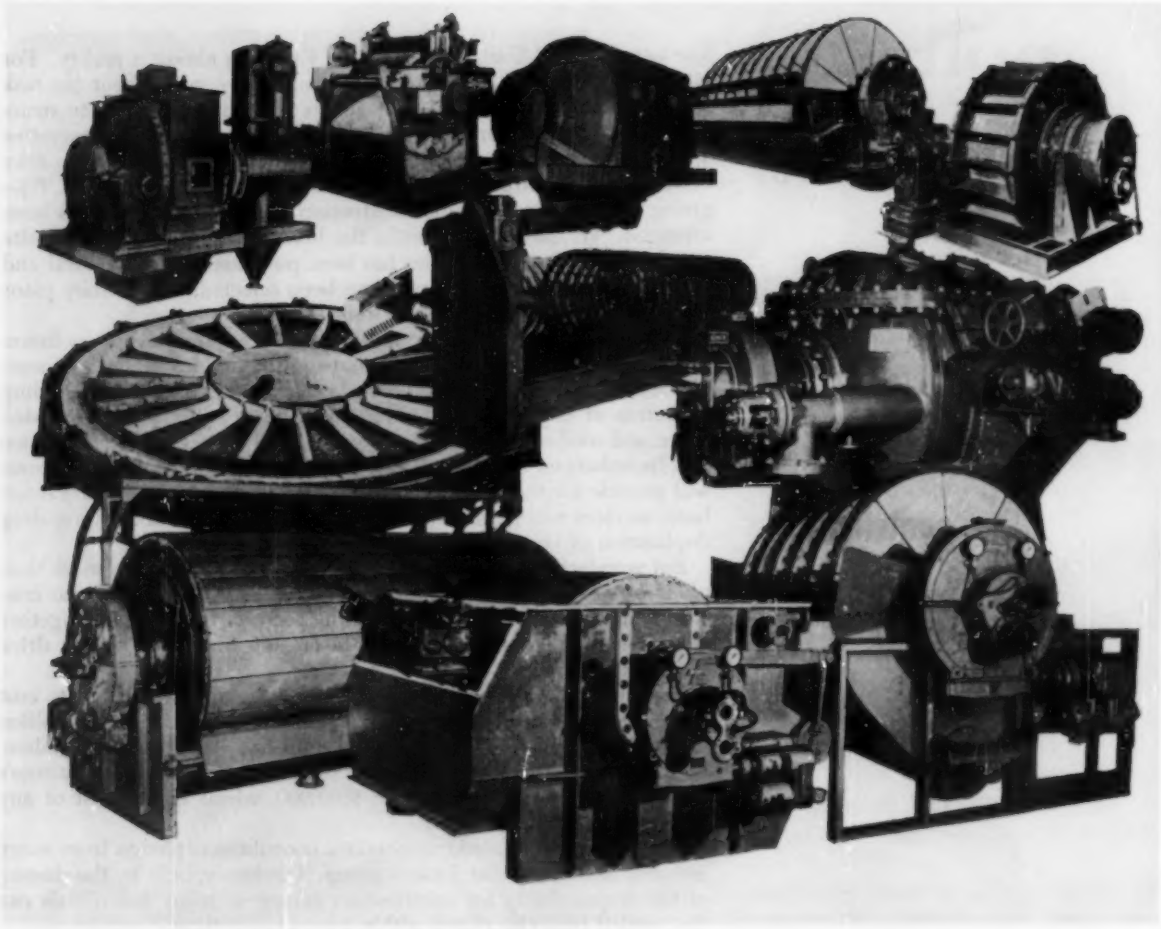
Efforts are being made to obtain a contribution pledge from every member of the Founder Society group. Obviously, only by the sharing of the responsibility for contribution among so many individuals can the needed funds be raised within a reasonable time.

Co-chairmen for the Institute's part of the general Member-Gifts drive are Sid Kirkpatrick and Walt Whitman. The campaign is being conducted through the Institute's Local Section structure, with field personnel nominated by the chairmen of the Sections.

Already these A. I. Ch. E. co-chairmen have contacted a select list of 250 chemical engineers and have raised more than $75,000 from these few. This leaves about $225,000, or 75 per cent, yet to be raised. Within a short time, every Institute member will be contacted by a campaign representative. Payments of pledges may be made over a period of three years and are tax deductible. Target date is October 15.

Only through generous giving by each member will the Engineering Center be a reality by 1960. And why should we not give, and give heartily, for this purpose? For the young chemical engineer, his contribution will be his investment in the future. For the older person, his gift will be a discharge of his debt to the past, and a tribute to the benefits and satisfactions he has derived as a member of the engineering profession.

When one of your local associates calls for your contribution pledge, consider what a "once-in-a-lifetime" opportunity you have to share in the support of the most significant and promising undertaking of our profession to date. The giving of your dollars for this worthy purpose will provide our nation with a United Engineering Center of which it—and we—can be proud. Its inspirational value will be without dollar measure, but its realization will come about only through the giving of all of us. J.B.M.



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8 - 349

PROCESS CONTROL

for tomorrow's plants

An over-all look at process control with emphasis on things of concern and interest to chemical engineers

Our way of life today is dependent upon the efficiency of our industrial economy. Tomorrow, it seems, our industrialization may well have to bear much of the responsibility for our nation's internal needs, and do so in a world of less convenient raw materials and greater competition from abroad. To meet these economic pressures as they occur will call for the most effective use of energy, materials, and human resources. One of the most promising means for achieving such effectiveness lies in the development and application of the concepts of systems engineering. "How well is my organization doing in preparing for the future?" might well be asked by the man in management. "How well am I doing as a chemical engineer in preparing myself for the expectations of the managerial economists of the future?" might be asked by the individual engineer. To be able to design, build, and economically operate plants to meet the probable needs of 1965 calls for extensive and careful preparation now . . . or at least very soon.

This *CEP* feature should answer many, if not all, of the questions in the minds of those who are, or will be, responsible for the processing facilities of the future.

Process control—major factor in chemical engineering

J. B. Roberts, *DuPont*

In the past few years a new engineering approach to control has been gaining rapid acceptance though it is as yet unfamiliar to many practicing chemical engineers. It is variously characterized in such terms as servo mechanism theory, dynamic analysis, and systems engineering: It employs methods based on sound physical principles, can be stated in specific mathematical language, and for the first time enables the systematic analysis of all facets of control on a truly quantitative basis. This systems approach can well have as major an influence on today's engineer concerned with productivity and uniformity as the unit operations had on the new chemical engineering profession of half a century ago.

What is the meaning of process control? Process control embodies the technology of keeping a process operating under the desired conditions and producing products of the desired properties in spite of upsets.

Process control as we are going to have to consider it is thus not just a matter of measurement and feedback; in one way or another, it touches on almost every aspect of the plant. Thus every chemical engineer will have to understand enough of the implications of this new technology for him to make intelligent decisions in the many technical areas affected.

While the basic concepts of control are certainly familiar, the practice of control rests predominantly upon two unique factors, both touched on only lightly in the conventional training of chemical engineers. One is an extensive knowledge of the techniques of instrumentation.

A second unique factor is a thorough understanding of dynamics. By dynamics we mean the characteristic response of systems to disturbances. Though little used heretofore in chemical engineering, the basic sense of dynamics is intuitive to all thinking people.

This dynamic sense unquestionably has value, but it possesses severe shortcomings. Being only intuitive, it does not form a satisfactory basis for engineering analysis. Being essentially nonsystematic in character, its transmission to others is seldom effective.

But are nonsystematic intuitive techniques adequate for 1958 and the next decade? A closer look at our technology reveals economic pressures arising inside and novel developments originating outside the chemical industry that are rapidly reducing the effectiveness of this earlier practice.

In the chemical field, the costs of wages and salaries continue to draw away from the prices received from sales of products. Economics thus necessitates continued mechanization of processes, extension of automatic control and streamlined clerical and service procedure to realize high productivity from plant personnel. Increasingly, it is essential that operating manpower be used to monitor processing performance rather than for manipulation and adjustment. Each such step requires added feedback devices, more automatic sequencing, and greater instrument centralization. In addition, increasing progress is being made in developing multifunctional equipment in which a single piece takes over the duties formerly handled by several pieces. Each step toward higher productivity and lower inventory makes the process faster acting and more sensitive to upsets. Such process changes frequently necessitate operation nearer an explosive concentration or a runaway temperature, and require instrument control that is significantly faster, more precise, and more reliable to maintain an adequate margin of safety.

Concurrent with these shifts in

continued

Condensed from papers in symposia on "Moving Forward in Process Control" presented at A.I.Ch.E. Jubilee Meeting, Philadelphia, 1958.

CEP thanks Page Buckley, DuPont, for his assistance in preparing this detailed condensation.

Major factor

continued

processing technology, and sparked by advances in aircraft and missiles, has come an explosive expansion in the production of instruments. There can be little doubt that the breadth of instrumentation currently available far outstrips the capacity of chemical engineers (and instrument engineers as well) to put it to effective use.

Even more significant as a recent development is the success of powerful servo techniques for quantitative analysis of control problems. Following World War II, these servo techniques were further systematized and applied to closely related problems of speed and position control for industrial machinery. Even more recently, trial applications in the process industries have demonstrated their high promise in a field where quantitative methods had been essentially nonexistent. The dynamic action of all the elements—both individually and collectively—in a control system can be analyzed, including the process equipment, the measuring instrumentation, the controllers themselves, and the automatic valves.

A related development closely paralleling the growth in acceptance of servo techniques is the increasing facility with which computers can be used to provide quantitative answers to complicated mathematical expressions. Digital and analog computers are now available to almost all technical groups; their use is frequently essential for the precise calculations needed for static design. In dynamics, they are being used to explore nonlinear effects and the performance of distributed and interacting systems. Simulation techniques have also proven valuable as a means of visually displaying—and thus explaining to other engineers—how design or operating variables might affect a proposed control system.

These new approaches will have further value—perhaps not immediately tangible, but at least of equal importance in the long run—in stimulating deeper inquiry into the transient phenomena of chemical processing—such as bubbling mass transfer, mixing, and high-shear viscous flow—and basic processing operations—such as formation of films, fibers, coatings, and droplets. Usually treated in steady-state form, these phenomena are in reality highly transitory in nature. Use of these techniques is already yielding significant results in the fields of bubbling and diffusion.

It is clearly up to the process industries to determine the dynamics of process equipment. Essential to this, but difficult to achieve, is the education of the chemical engineer in dynamic methods. The usual curricula over the past twenty-five years has provided little in mathematical background to serve as a take-off point for the operational techniques employed. Many years will elapse before graduates with such academic training will constitute an appreciable fraction of practicing engineers. Intensive, specialist training is clearly needed now for those engineers who will participate actively in instrumentation and dynamic analysis. The problem for other engineers already in industry is primarily one of acquiring sufficient of the principles and the significance—but avoiding unnecessary detail—to enable intelligent action in the many areas where control problems are thrusting forward.

Chemical engineering process dynamics

E. F. JOHNSON, *Princeton University*

As dynamic behavior may be regarded as perturbed behavior, the characterization of process dynamics may be made on the basis of the response to particular perturbations. Most generally this characterization can be made by the integro-differential equations describing the response of the particular component or system to a general forcing. Where such description is not possible, the characterization must be empirical and is generally presented in graphical form as the response to particular kinds of forcing. In many cases process dynamics may be described with sufficient engineering accuracy by linear differential equations with constant coefficients, which are readily solved by the methods of operational calculus using the Laplace transformation. The Laplace transformation may be regarded as a device for converting differential equations into algebraic equations which may be manipulated by the rules of algebra into forms from which the inverse transformation gives the desired solution of the original differential equation. The equation may then be reorganized to express the ratio between the forcing function and the response. This ratio is called the transfer function, which is a compact and complete identification of the system dynamics.

Certain elementary processes may be represented by first order linear differential equations and therefore have a first order transfer function or transfer stage. Some examples are continuous stirred tank reactors involving mixing processes under steady flow and isothermal first order chemical reactions; equilibrium contact stages in phase change physical separation operations; heat transfer processes involving a single overriding thermal resistance and corresponding capacitance; liquid level and inventory processes in tanks; and pneumatic processes involving a major flow restriction and corresponding volume chamber.

Usually the various typical processes behave as systems of higher than first order.

Typical examples of systems behaving as second order stages which oscillate when disturbed are simple systems with inductance effects and systems with inertial effects. Manometers and pressure springs such as bourdon gauges and helices are familiar examples. Nonoscillatory second order systems, that is, systems for which the damping ratios exceed unity, include all systems which can be made up of two simple first order stages in series. Heat exchange processes and coupled stirred reactors are typical examples.

Whereas the first order transfer stage is sometimes called a first order transfer lag, the pure time delay may be called variously a dead time, a distance-velocity lag, a transport lag, or a sampling lag depending on how it arises. The principal characteristic of the pure time delay is that it holds up signals in time but does not otherwise affect them. In the process systems time delays result usually from the fact that a finite time is required for material to flow between two points, and during this time the point downstream cannot be affected by the instantaneous behavior at the point upstream.

The transient response of a pure time delay is merely a displacement in time of the input signal, and the duration of the displacement or delay time is the characterizing parameter.

All systems for which the descriptive parameters cannot reasonably be presumed to act at points in the system are distributed parameter systems.

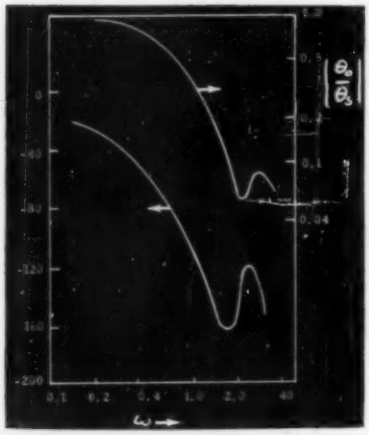

Figure 1. Magnitude ratio and phase for distributed forcing.

Such systems are represented by partial differential equations. An example would be a long double pipe heat exchanger.

Cohen and Johnson (*2*) present a straightforward procedure for analyzing such systems and Takahashi (*9*) has tabulated the transfer functions for a wide variety of specific cases. One interesting property of distributed systems which are forced sinusoidally in a distributed property is that the frequency response characteristics exhibit resonances at frequencies corresponding to reciprocal residence times. In Figure 1 frequency response characteristics for a double-pipe heat exchanger show these resonances. The output is the exit water temperature from the inner pipe and the input is a sinusoidally forced steam temperature distributed throughout the jacket.

Another simple but important example of distributed parameter systems is the transmission line. Rohmann and Grogan (*7*) describe in detail the behavior of pneumatic transmission lines and how that behavior may be estimated reliably.

Numerous authors have described the use of step forcing and pulse forcing in the elucidation of process characteristics and mechanisms. Although the emphasis of these works has not been directed toward characterization for control purposes, the results have pertinence to the control problem. Much of this effort has been concerned with flow distributions and diffusional processes within various kinds of contacting systems. A typical example is the work of Lapidus (*5*) in which residence-time studies were made on a small packed column through which gas and liquid phases flowed concurrently. Both step and pulse forcings were applied to the concentration of either phase. Analyses of the transient concentrations in the exit streams permit an interpretation of the effects of flow distributions and diffusions within the pores of packing materials.

In contrast to transient studies the direct measurement of frequency response characteristics by forcing the process element with steady state sine waves of varying frequency is time consuming. A detailed survey of available apparatus for generating sine waves and obtaining frequency response data is given by St. Clair, Erath, and Gillespie (*8*).

A large number of frequency response studies have been reported in recent years. Illustrative of this effort is the book edited by Oldenburger (*6*) based on the international symposium on frequency response at New York in 1955. Although the great bulk of work involving sinusoidal responses has been directed toward control applications, frequency response techniques have been used as far back as the middle of the last century in studies of system properties and process mechanisms. Angstrom (*1*) in 1861 used periodic forcing to measure the thermal conductivity of a metal rod. More recently Deisler and Wilhelm (*4*) used frequency response techniques to measure interparticle and intraparticle diffusion and axial diffusion in systems of gas flowing through fixed beds of porous particles. Kramers and Alberda (*11*) used the technique for measuring longitudinal diffusion in liquid flow through packed columns.

Voetter (*10*) has determined the response of concentrations at the top of a distillation column to disturbances in feed concentration. The experimental results are in good agreement with results calculated theoretically using difference equations to accommodate the stagewise operation.

At high frequencies the determination of the sinusoidal response is complicated by the attenuation of the output signal and the masking effect of the random signals (noise) in the output. By means of correlation techniques using automatic computation it is possible to eliminate the effects of the noise and get the frequency response characteristics. Cowley (*3*) has demonstrated the efficiency of this procedure using an analog computer on a simulated process and on a real thermal process. Reliable frequency response data are obtained even when the noise to signal ratio exceeds two orders of magnitude.

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Chemical reaction system dynamics

A. S. Foss, *Du Pont*

With today's trends toward continuous, low-holdup, and rapid-reaction processes, emphasis is now shifting toward understanding the dynamics of chemical reactors. Our present knowledge of reactor behavior lies almost entirely in the realm of what one might call its unperturbed performance.

In a sense, the design and study of unperturbed reaction systems have, in the past, encompassed an indirect examination of reactor stability in the face of upsets. For example, rates of conversion and heat removal might be adjusted by trial to avoid the occurrence of hot spots or the runaway of an entire reactor. One might date the beginnings of studies in reaction dynamics as far back as 1908 when a chemist named Hirniak demonstrated mathematically the possibility of damped concentration oscillations in an autocatalytic reaction system (*15*). Further studies of Lotka (*19*) examined sustained oscillation in similar systems. In modern terminology, one might classify these as studies of chemical reactions with positive feedback. During the past two years, Amundson and co-workers at the University of Minnesota have made outstanding contributions to our knowl-

continued

Dynamics

continued

edge of the dynamics and stability of industrial reaction systems (*1, 4, 5, 22*).

To illustrate the principles involved, a simple case will suffice, that being a continuous-flow stirred-tank reactor in which the exothermic reaction A → B takes place.

For the problem at hand, the reactor behavior is completely described by simple heat and material balances. The equations below are the transient forms of the heat and material balances and refer to the reactor shown schematically in Figure 2.

$$V\left(\frac{dx}{dt}\right) = q\,(x_o - x) - V \cdot x\left(pe - \frac{E}{RT}\right) \qquad (1)$$

$$Vc\rho\left(\frac{dT}{dt}\right) = qc\rho(T_o - T) - V'a(T - T_c) + (V \cdot x)(-\Delta H)pe - \frac{E}{RT} \qquad (2)$$

where:

x = concentration of reactant A in reacting mixture

T = temperature of reaction mixture

T_o, x_o = temperature and concentration of entering reactant stream

T_c = mean coolant temperature

t = time

$pe - \frac{E}{RT} = k$ = reaction rate constant, the Arrhenius law

V = volume of reaction mixture, assumed constant

$(-\Delta H)$ = heat of reaction

q = volumetric flow rate

c = heat capacity of reaction mixture, assumed equal to heat capacity of feed stream

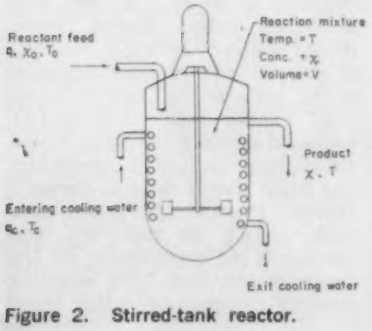

Figure 2. Stirred-tank reactor.

ρ = density of reaction mixture, assumed equal

U' = coil heat-transfer coefficient

a = coil heat-transfer area

In the above formulation, complete temperature and concentration uniformity throughout the reactor is assumed, and the thermal capacity of the vessel is considered negligible. Before proceeding, some interesting observations may be made by consideration of the steady-state form of these equations; that is, when the terms on the left-hand side representing the rate of change of composition and temperature are identically zero. These steady-state relationships are easily derived by first determining from Equation (1) the steady-state composition level as a function of temperature denoted x_s (T). The heat balance may then be written:

$$Q_R = Q_G$$

where:

$$Q_R = qc\rho\,(T_o - T) + V\acute{a}(T - T_c)$$

= rate of heat removal

$$Q_G = V' x_s\,(T)\,(-\Delta H)\,pe - \frac{E}{RT}$$

= rate of heat generation

Fig. 3 is a typical plot of Q_R and Q_G vs. temperature, indicating the possibility of three steady states: A, B, and C. The functions Q_R and Q_G on Figure 3 should be ignored momentarily. Van Heerden reasoned qualitatively that the reactor would be stable to small fluctuations in temperature at points A and C (that is, it is self-regulatory at these points) but unstable at Point B (*23*). Positive perturbations in temperature from either of the Points A or C result in a heat removal rate greater than the rate of heat generation; the natural tendency is thus to decrease the positive temperature deviation. Negative perturbations are likewise reduced since heat generation rates exceed heat removal rates. At point B, on the other hand, positive perturbations give rise to a runaway of reactor temperature toward Point C since more heat is generated than is lost. Negative fluctuations result in a quenching toward Point A.

An analysis of reactor stability is of interest because one has no assurance *a priori* that the particular operating point selected is a stable one; as a matter of fact, Figure 3 indicates that there is considerable chance that an unstable point will be chosen. (Point B). The chance for unstable operation is even more clearly detectable by construction of a signal flow diagram as suggested by Campbell (7). Fig. 4 shows such a diagram for the stirred-tank reactor in question.

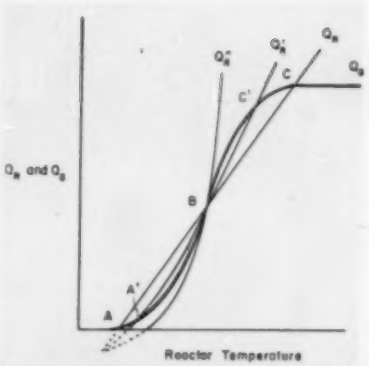

Figure 3. Heat generation and heat removal.

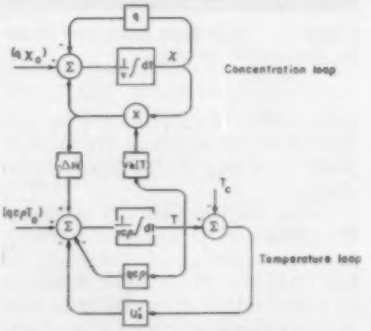

Figure 4. Signal-flow diagram.

The appearance of a positive feedback loop in temperature is indeed indicative of trouble.

Reactors such as the one treated above are seldom, if ever, operated without some regulatory action. In fact, one may want to operate a reactor in a region where the reactor is definitely not autoregulatory (see Point B of Figure 3). If this is the case, control action is indispensable, and the question arises as to just what kind of control system is adequate. Stability limits of reactors with control action is thus worth consideration, particularly when an analysis of the above type labels the operation point as one to which the reactor has no natural tendency. For the reactor in question, Equations (1) and (2) indicate that one may regulate any of several parameters; namely, the inlet concentration and temperature, coolant temperature, or the coolant flow rate. One also has the choice of using either concentration, x, or temperature, T, to sense deviations of the reactor from the steady state. To illustrate how one might determine the merits of a particular control system, Aris and Amundson (*1*) have investigated the stability of a reactor controlled by variation of coolant flow rate, q_c. Three modes of ideal control (proportional, derivative, and integral) were studied and temperature and

composition were both considered as the measured variable. Aris and Amundson have also treated the case of "imperfect control" by considering the dynamic characteristics of the control loop as well. If one assumes the transfer function of the control loop to be a rational polynominal, a stability analysis may be developed similar to the one just described.

Generally, the frequency response of the reactor is the most popular method for characterizing dynamic response. Frequency-response plots called Bode diagrams may be constructed to facilitate computation of control requirements.

Bilous *et al.* (*6*) have derived frequency-response relations for a stirred-tank reactor by a method equivalent mathematically to the one demonstrated above. They have tabulated the transfer functions for several commonly occurring kinetic systems and have treated reactors in series and tubular reactors as well.

Linearized procedures provide information on dynamics and stability only at localized regions of reactor operation. One is often interested in the reaction system in the large, that is, to determine the best reaction path to reach a given steady state or to determine the fate of the reactor in the event of a runaway. The so-called phase plane of nonlinear mechanics is ideally suited to mapping reaction trajectories in the concentration-temperature plane. Such a map is shown in Figure 5. Aris and Amundson (*1*) have presented an outstandingly lucid description of the application of this technique to the stirred-tank reactor considered above.

Figures 5, 6, and 7. Phase plane trajectories—stable control, unstable control, and no control, respectively.

Theoretical treatment of the dynamics of distributed reaction systems (e. g., tubular reactors) is considerably more complex than for systems with lumped parameters. Systems of nonlinear partial differential equations (rather than the ordinary type) are now needed to describe the reactor's behavior and, unfortunately, one can obtain no help from nonlinear mechanics in the linearization and solution of these equations. And too, the problem is much more extensive than the stirred-reactor problem. For example, reaction may take place in an empty tube or may occur on catalyst particles within the tube. There may or may not be axial mixing of the fluid. There may or may not be radial temperature and concentration gradients. Temperatures of the fluid and catalyst may differ widely, and there may be temperature and concentration gradients within the catalyst particles themselves. Fortunately, it is quite unlikely that all of these phenomena will present themselves in any one reaction system. This usually comes about due to the presence of what is commonly called a rate-controlling step. That is, in the series of events that lead to the formation of a product, there often is one step in this chain whose rate is slow compared to the rates of the other steps. For example, the rate of transfer of a reactant from the fluid stream to the catalyst surface may be so slow that one need not even consider the rate of chemical conversion in his analysis. Many other complications are also dissolved. It is such circumstances that often permit sweeping simplifications in the steady-state design of tubular catalytic reactors, and it is these same considerations which my lead to some success in understanding their dynamic behavior. The problem is challenging.

In spite of these difficulties, a good start has been made. Bilous and Amundson (*5*) have given approximate methods for deriving the transfer matrix for empty tubular reactors. Further, the stability of packed tubular reactors has recently been investigated theoretically by Cannon and Denbigh (*8*), Hoelscher (*16*), and Barkelew (*2*).

Simulation of chemical reactors on general-purpose analog computers has become a popular and powerful method for investigating reactor stability and parametric sensitivity. In essence, the analog computer merely offers an alternate method of solution of the original reactor differential equations. This method of analysis is quite well suited for evaluating the performance of proposed reactor control systems. Trouble-shooting of existing reactors is also easily handled by the analog because direct correspondence can be made between potentiometer settings and parameters familiar to operating personnel—parameters such as coolant rate, feed temperature, etc. Furthermore, the solutions need not be restricted to the linearized cases, since present-day computers are entirely capable of handling the nonlinearities. Analog computation of time-dependent behavior is restricted, however, in the rigorous sense to reactors with lumped parameters, since the computer has only one independent variable—time. Nevertheless, some attempts have been made to simulate reactor systems with distributed parameters by breaking them up into a finite series of lumped systems.

An analog computer might be used, for example, to calculate the phase-

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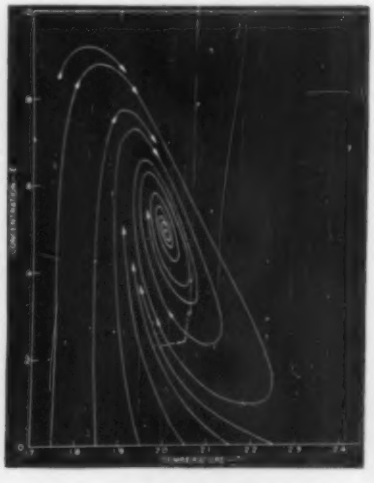

Dynamics

continued

plane trajectories of a stirred-tank reactor and obtain information similar to Figures 5, 6 and 7; this has been done by Bilous and Amundson *(4)* by programming Equations (4) and (5) and by having the computer plot concentration vs. temperature directly rather than obtaining solutions as functions of time. Or one may easily determine transient and frequency response by suitably forcing an input variable. The frequency response is useful, of course, only if one contemplates using the information in a linear analysis. In this connection, an interesting analog study of transients in a stirred-tank reactor has been reported by Ehrenfeld *(14)*. The nonlinear differential equations were solved by analog computation for their response to step inputs of various magnitudes. Comparison of these solutions with the solutions of the locally linearized equations revealed that a linear analysis describes the dynamics quite satisfactorily for perturbations of ±3%. Should one be using a high-gain control loop around the reactor, the linear analysis might prove adequate for deviations of ±10%. One thus has some indication of the range of the applicability of the transfer functions given by Equation (14).

An analog study of transients in a packed-bed reactor (a distributed system) has been attempted by Batke *et al.* (3) in order to determine causes for cycling observed during actual plant operation. For programming purposes, the reactor was broken up in the axial direction into a series of four sections in an attempt to adequately describe the distributed nature of the system. The kinetics of the reaction were simple, and fluid-solid interactions were neglected. The use of this technique to study systems slightly more complex quickly complicates matters. As many as a hundred amplifiers and several nonlinear components are rapidly consumed as soon as one encounters more than one reaction and important solid-fluid interaction. Moreover, there is no assurance at the present time that this method of representing distributed systems yields quantitatively meaningful results. The technique is an interesting and potentially powerful one, however, as it does afford considerable qualitative insight. It is sure to receive more attention.

Experimental determination of the dynamics of chemical reactors is a difficult task, and most likely this is a major cause for the lack of knowledge of actual dynamic behavior.

A brief account of frequency-response tests on an "exothermic process" has been given by Cowley *(9)*. His paper is concerned with measurement of the dynamics of noisy processes, however, rather than the process characteristics themselves. At the moment, all other experimental activity appears to be centered in the universities where emphasis is on educing fundamentals of specific physical and chemical effects via the technique of dynamic measurements. As examples of this, frequency response of the absorption of sulfur dioxide from air into water on a sieve tray was measured by Jardine to determine rates of mass transfer when accompanied by chemical reaction in the liquid phase *(24)*. Others have made dynamic measurements on packed and fluidized beds with no chemical reaction occurring primarily to study the nature of fluid mixing in chemical reactors *(11, 12, 13, 18, 20, 21)*.

When working with very rapid reactions in high-velocity flow, one often encounters fluctuations in flow and pressure induced by the reaction system. This case is analogous to rocket-motor stability problems. Crocco and Cheng *(10)* have treated this problem in some detail, considering both concentrated and distributed combustion systems in an attempt to describe low-frequency "chugging" and high-frequency "screaming." Some of their techniques might be used profitably in chemical systems.

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Measurement aspects of process control

A. R. Aikman, *Schlumberger*

It has been said that "when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind . . ." *(1)* To which might be added that if measurements are poor in quality and delayed in time, process control based on these measurements will be of a meager and unsatisfactory kind.

Since the beginning of process control, engineers and scientists have, in the course of their attempts to "measure what they are speaking about," developed a remarkably wide array of equipment.

For practical reasons, process measurements made with this equipment are generally divided into two broad classes:

(a) Environmental: as the name implies, these are measurements of temperature, pressure, flow and other quantities which govern the physical environment in which the process takes place.

(b) Analytical: where the measurement is a direct expression of chemical composition.

Whatever the measurement may be, the control system designer is concerned with two kinds of parameter defining the performance of the instruments; "static" characteristics such as accuracy, dead-zone and reproducibility; and "dynamic" characteristics. Absolute accuracy, or error, of a measurement is not necessarily detrimental to automatic control, where it is generally more important that a variable be held at a constant rather than exact value.

"Dynamic characteristics" is an expression of the temporal behavior of the measuring instrument when proc-

ess conditions change. The literature abounds with this temporal data in guises such as "frequency response," "step response," "transfer function," etc. Perhaps the simplest expression and the one easiest to grasp is "time-lag."

The profound influence of measuring lag on automatic control was forcibly pointed out by Behar in 1948 (3) but it is only within the last five years or so that quantitative data have become available.

Consider the example shown in Figure 8 whose response to a disturbance is shown in Figure 9. As the measuring lag is diminished by a factor of 9, the fidelity of measurement is improved by a factor of about 3; in addition, the speed with which the initial deviation is reduced is improved by a factor of 3. Generally speaking, it seems desirable to reduce measuring lag to substantially less than the value of the main process-equipment lags.

Of the so-called static characteristics, the absolute error in measurement has perhaps the least significance from a narrow control point of view, because error will not affect the performance of a closed-loop control, it will only affect the performance of the process. However, instrument characteristics such as reproducibility (where lack of reproducibility is caused by dead-zone or hysteresis) my have also a dynamic effect on control.

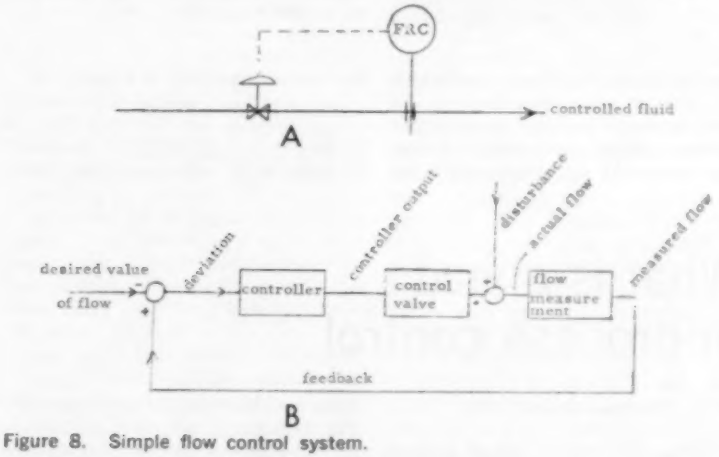


Figure 8. Simple flow control system.

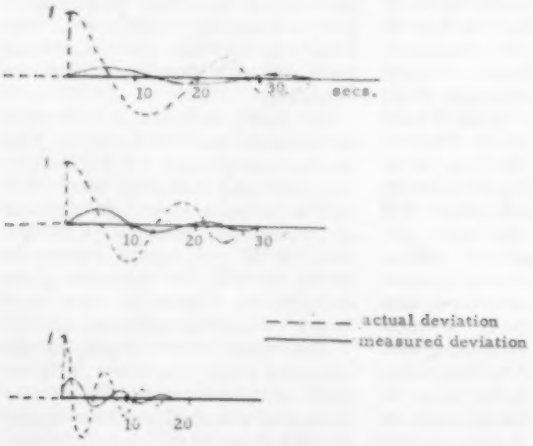


Figure 9. Response of flow control systems to disturbance.

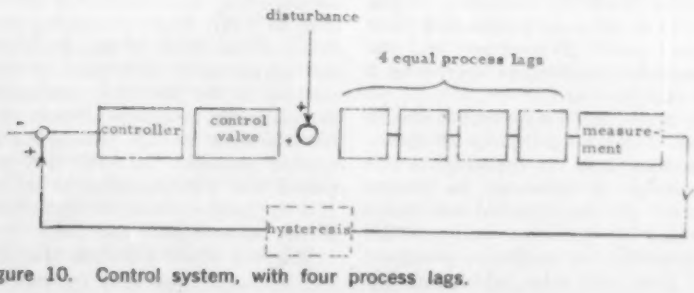


Figure 10. Control system, with four process lags.

To demonstrate the effect of instrument hysteresis on control, we set up an electrical analog of a fourth-order process (which might correspond in practice to a portion of a fractionating column, or a water-jacketed reaction vessel) and controlled it by a simulated proportional-reset-and-rate controller, Figure 10. The response of the system to an injected step-disturbance was as expected, Figure 11. We then introduced a simulated hysteresis zone between the point of measurement and the controller; the half-width of the zone was 1% of the measuring range. With the same controller adjustments, the system burst into violent sustained oscillations after the disturbance was applied, and even after the controller gain was halved, the system performance (Figure 12) deteriorated greatly from the ideal one. The effect seems out of all proportion to the magnitude of the hysteresis zone, but hysteresis and similar phenomena are inherently nonlinear in nature.

Many new types of analytical instruments have become available during the last five years, and the reliability of some types, as proved by monitoring service, has reached the point where they can be used as active components in the automatic control loop. A recent statistical survey (2) disclosed that a surprisingly high percentage (about 30%) of process-type analytical instruments are used for automatic control.

Among the special characteristics of analytical instruments (control-wise), one may list the following:

1. Analytical instruments commonly work on samples which are abstracted from the main stream and carefully conditioned before they are presented to the instrument for analysis. The careful transportation and conditioning of the precious sample takes time; it is a truism to say that when you add an analytical instrument, you add dead-time (transport lag). The effect of dead-time, in even small amounts, may be highly damaging to the quality of control achieved.

2. The chemical composition which

continued

Measurement aspects

continued

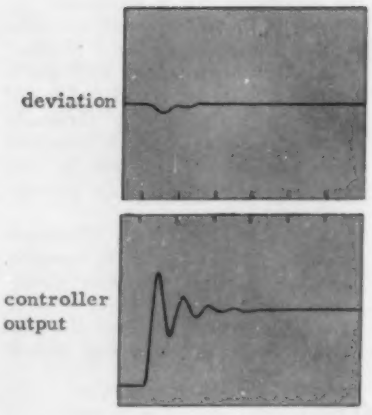
is measured by the instrument may not be a simple function of one conveniently-manipulated variable, but may be a function of several variables (some of which are elusive to measure and hard to manipulate). To fully utilize the analysis information in order to control the process at optimum conditions, some form of computation may be necessary.

3. The output data from the instrument may not be continuously available to the controller, but may be intermittent, that is, the data are sampled. This is inevitable with such instruments as vapor fractometers, mass spectrometers, nuclear magnetic resonance spectrometers. Process control technology today is essentially built around continuous-data systems, and the use of sampled data dictates adjustments, at least conceptually.

The feature of sampled-data systems which distinguishes them most markedly from continuous-control systems is the fact that most of the time the system is operating under open-loop conditions. Since information is available to the controller only at the instance of data-sampling, anything which happens in the process between data samples is not discovered and cannot be corrected until the next sampling instant.

The performance of every sampled-data control system is strongly influenced by the sampling period T, or rather by the ratio of this period to the time-constants of the plant to be controlled. When T becomes very much smaller than the plant lags, the system tends to behave as though data were available continuously to the controller. When T is much larger than the plant lags, the system will be under open-loop conditions much of the time and the response in the presence of disturbances cannot be expected to be as good as in truly continuous (e. g., proportional reset and rate) control.

Looking to the future of analytical instruments, one may project a short distance by extrapolating from present activity. Analytical measurements (particularly if nondestructive in nature) which are made today only in research or control laboratories, such as those based on NMR, electron spin resonance and various nucleonic techniques can be expected to graduate to on-stream use in a reasonable length of time. Crystal-gazing of this order, however, will predict developments that must fall short of reality because at any time a completely novel technique may be applied which will give a new dimension to old measurements (as the vapor-liquid partition column gave a new dimension to the old art of measuring the thermal conductivity of a gas).



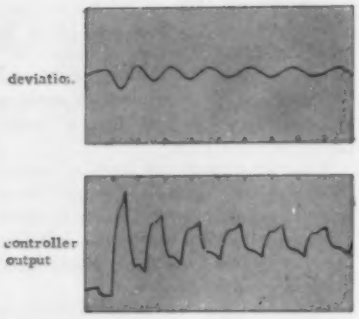


Figure 11. (left) Response of control system.
Figure 12. (above) Effect of hysteresis on control response.

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What is ahead in process control

W. E. Vannah, *McGraw-Hill*

To find out what is ahead in process control, let us consider some of the influences at work. The first of these is the welding of pneumatic, electronic, and hydraulic control equipment. Eighty-five percent of all process control loops transmit and control with compressed air. There is every likelihood that the volume of pneumatic and mechanical transmitting and controlling instruments will not decrease. They do their jobs cheaply and well. But it is just as certain that there will be an increase in the use of electronic process control instruments, loggers, operator-guide computers, and computing control systems, probably in that order.

Another influence is the trend in measured variables. While composition measurement is making an impressive ripple by increasing 10 per cent or so per year, it rides on a great ground swell of inventory and environment measurement, increasing 2 per cent per year.

A third influence is instrumentation costs. Two characteristics of instrumentation costs are important to this discussion of influences on process control: (1) their installed cost, where the cost for continuous-type processes is twice that for batch-type processes; (2) their price index, which currently hikes up about 11 per cent per year. The percentage cost of instrumentation decreases as the total process cost increases. A three-year projection of what is ahead in process control must include the fact that initial instrument costs and their installation costs are increasing.

The fourth influence is investment in research and development. Can process control stand still if the chemical processing industries spent $950 million on research and development in 1957 and plan to spend $1,130 million — a 19 per cent increase — by 1960? Or will the processes under development present no new challenges for measurement and control?

The topics of the papers of this symposium are concerned with aspects of process control—mechanical dynamics, chemical reaction dynamics, and organization for systems engineering—that were considered unrealistic in 1947. More convincing evidence of the reality of new problems and opportunities presented by this research is the fact that instrument manufacturers currently devote 2-3 cents of their average sales dollar to applied research. In 1957 they reported that they expected to up by 1/3 the gross expense on applied research between 1957 and 1960.

It seems almost axiomatic that the

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. . . history

Fifty years of automatic control

D. J. BERGMAN, *Universal Oil*

Oil refineries have been for years the most highly instrumented for the times. In 1908 even a crude shell still might have a recording thermometer, and the pressure stills for thermal cracking which came into being in the course of a few years were fully instrumented with pyrometers, large sensitive pressure gauges, and frequently speed governors on reciprocating pumps to control the flow of charging stock. Not until 1925, however, were controller and recorder functions combined in one instrument.

In early years primary control was in the mind and hand of the cracking still operator; the stopwatch, hydrometer, and thermometer all were tools of his trade. For convenience in controlling pump speed by hand and to minimize the temperature changes that seriously affected the speed governors, the pumps were commonly located in the receiver house with the instruments, and the atmosphere was not always the best.

Articles in 1924 showed the application to fractionating columns of automatic temperature control with air pilots. There was a valve in the reflux return to the top bubble plate, a valve in the steam line to a reciprocating reflux pump, and a valve in a by-pass between the inlet to a water coil. Lastly, there is a double valve arrangement, one in the line and one in by-passing the coil, respectively, opening and closing with increasing air pressure.

A big problem of the pioneer control engineer was valve sizing. If the instrument salesman was asked to recommend the size of a pressure governor for a reciprocating steam pump, his answer frequently would be, "What size is the steam line to the pump?" Calculations based on the estimated steam consumption and pressure differential which resulted in installation of a ¾-inch valve in a two-inch steam line were considered not quite cricket.

So things went in the transition period. As late as 1930, C. E. (Doc) Mason, a physicist, who was responsible for a large number of experimental installations for the Foxboro Company, had this to say in the *Oil & Gas Journal*.

"Perhaps the most striking impression created by a visit to one of the old refining districts, such as Oil City, Pennsylvania, is a realization of the vast improvement in refining methods.

"In briefly analyzing these developments, we cannot help but feel that one of the major factors in obtaining such concentrated and efficient methods is the application of the principles of automatic control. We might even say automatic control, not in the sense of control being obtained by the use of automatic instruments, but in the sense that the equipment is designed by refinery engineers so familiar with the physical reactions that these reactions are completely balanced within themselves."

During the period between 1930 and 1935 there was a major movement throughout many industries toward utilizing automatic control to do jobs that had formerly been the tedious duty of a man, such as flow, pressure and level control, firing control of heaters, and temperature control at the top of fractionating columns. Not only did these controls reduce operating manpower required on units, but the uniform and continuously watchful supervision of the controller enabled plant capacity and product quality to be held at higher levels with consequent high economic gains. This last idea was still difficult to sell, and the cost of automatic control often held back its installation, if a corresponding reduction in operating labor could not be shown to result.

One of the major factors in the acceleration of the use of automatic control during this period was the development of reliable standardized equipment by a number of manufacturers. Furthermore, manufacturers began to standardize cases, so that pressure, temperature and flow instruments would all fit the same control board space. Standardization of air pressure control range was of great value in multiple instrument systems. Perhaps the greatest factor was the improvement in accessibility, through using pyrometer instruments which could be installed on the main control board instead of locally.

In 1934 automatic control moved toward professional recognition. In the fall of the year a group of people associated with manufacture and use of control equipment, met under the auspices of the American Society of Mechanical Engineers. Out of this meeting developed the present Instrument and Regulators Division of A.S.M.E. with a membership of about 2,400 which holds an annual Division meeting and presents papers at general A.S.M.E. meetings, and also cooperates with other technical groups interested in automatic control.

About the same time numerous local organizations of instrument engineers and technicians were being founded, such as the Chicago Society for Measurement and Control. These groups banded together to form the Instrument Society of America, incorporated in 1946 and now numbering nearly 11,000 members.

Between 1935 and 1940 the use of automatic control equipment became sufficiently standardized so that when World War II called for tremendous expansion of refinery facilities, automatic controls were ready to keep in smooth operation huge catalytic cracking, gas concentration, alkylation, isomerization, and other processes for making aviation gasoline components.

The problem now was the size of control boards. With the increased complexity of processes these had grown to a length of over 80 feet. Such a board required almost continuous logging on the part of one helper, and the operator needed roller skates to flit from one key instrument to another during a plant upset.

Graphic panels

Although flow chart panel boards had been built into portions of a number of units over many years the graphic panel and miniature instruments came into use in 1949.

It was found that this led to improved steadiness of control, through use of locally mounted controllers, with transmitters connected to recorders and to manual control stations at the board. The shortened control loop made a noticeable difference in smoothness of plant operation.

An important parallel contribution was the fact that no "live" lines containing oil or gas entered the control house. This was a great contribution to plant safety, since the control room could now be completely gas free.

The advent of the electronic controller was timely in view of modern control thinking. This involves data reduction installations, in which electrical impulses from the various instrucents of a processing unit or even a complete refinery may be brought into a central station where temperature, pressure, flow and other readings can be processed, integrated, recorded and printed by a digital computer to afford complete plant accounting. For the accuracy required by the digital computer, electrical signals are needed.

What's ahead

continued from page 44

first effect of process research on instrumentation will be the generation of new measurement and control instruments. This phase is underway now and should run through 1962. About seven years after the boom in process research started, that is, by the mid-1960's, the consumer goods industries should experience "the greatest surge of capital investment in all history: . . . (radically) new processes . . . , which are the slowest to develop, will come into play" (*1*). By then the new processes can, and probably will, be fully automatic.

A fifth influence is the advance and interchange in control technology.

As an unconventional example of control technology cross-over from other industries, consider the human operator as a dynamic control component. Information on the dynamics of humans in tracking tasks is available in unclassified reports by Franklin Institute, the Air Force, and the Navy. While the example may seem odd, the information has worthwhile application in process control rooms. A correspondent from the chemical processing industries explained why, when he wrote me: "Fitting in the characteristics of the human 'controller' is of growing importance. We have, in our present control rooms, removed much of the routine work that an operator used to do. But we have at least two operators per shift per control room, so we should try to make the most effective use of these men. We have made a few studies in which the operator is treated as a linear, continuous controller, and have considered studies in which he operates as a sampled-data controller." Target tracking is functionally similar to control from computed guides displayed before a human controller. The time scale is an order-or-two different, but the principles of designing an aided display are identical for target-tracking and guide-following.

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Organization for chemical process control

J. Williams and J. O. Hougen, *Monsanto*

How does a chemical or petroleum company organize for process control research?

Figure 13 gives a suggested organizational chart of a central company organization to carry out this work. Groups are included for the functions of plant testing, instrument development and evaluation, and theoretical investigations. Also included is the function of education of which we will say more later. A total of six to twenty-seven engineers and five to twenty technicians are considered necessary, depending upon the size of the company and type of computer facilities available.

The large portion of the engineers included in the Theory and Analog Computer Group is dictated by the voracious appetite of analog computers for problems. This is especially important when the theory group engineers must carry the problem completely from the conceptual stage through to solution. If the company's regular design and production engineers were to set up their own computer problems, only a small number of personnel would be necessary in the group. These latter would be needed only to maintain and operate the computer. However, this would probably not be the case where problems of the type we are discussing here are concerned.

As more and more publication of results of process dynamics research is made by the companies involved, the emphasis in the work of a group such as described above may change from the more basic process and equipment dynamics to work of an applied nature such as in the optimizing of specific processes.

It is vitally necessary that the engineering personnel of the section have a knowledge both of automatic control theory and of chemical engineering practices. However, as was mentioned earlier, personnel with training of the type necessary to carry out systems engineering investigations are quite rare among chemical engineers. On the other hand, many electronic engineers have a good background in general control system theory and in analog computer operation but these lack a detailed knowledge of the types of problems which arise in chemical process development, dynamics, and automatic control.

It therefore seems highly desirable to combine the breadth of knowledge of each of the available types of personnel by having each project carried out by a team of two engineers, one chemical and one electronic. Thus the electrical engineer's knowledge of control systems theory and practice in general can be combined with the chemical engineer's knowledge of specific chemical systems. Such an arrangement has been used at Monsanto for the past year and has already achieved exceptional results. While these engineers had some difficulty in the beginning developing a common nomenclature, it was soon found that mathematics is a common language between all engineering disciplines. This arrangement has also proven itself to be an extremely good training system for both types of engineers.

Because of the mathematical background necessary for all engineers, both chemical and electronic, engaged in this work, the masters degree or its equivalent or an even higher level of training is required.

As we have said, the major effort in *process dynamics* and *control studies* is being made at present by people

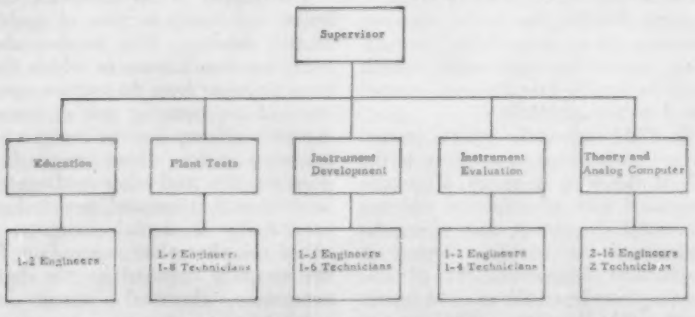

Figure 13. Suggested organizational chart, central process control group.

outside of the chemical engineering profession. But maximum progress in the application of systems engineering technology to the chemical processing industries will occur only when the chemical engineers become skilled in process control and dynamics. Only then will they be capable of specifying, designing, and supervising *controlled systems*. Should they let the acquisition of this information be carried out by others by default, then chemical engineers may be playing a secondary role in their own field. It is quite likely that the difficulties existing today in applying automatic control techniques most effectively to the process industry are due to the fact that chemical engineers are not generally the guiding participants.

In order to alleviate this situation, a special company-sponsored, educational program has been established by the Monsanto Chemical Company in cooperation with St. Louis University. This is a full-time, directed academic leave program. It has enrolled several key company personnel in a curriculum consisting of senior undergraduate and graduate courses. For the most part these are regular university courses offered by St. Louis University. The program occupies a full calendar year, consisting of two summer sessions followed by a regular two-semester academic year.

The personnel involved in chemical process research and development and in chemical plant design have of necessity rather diversified backgrounds. These may include mechanical, or electrical engineers; chemists; or physicists, as well as chemical engineers. To have maximum effectiveness, the program must accommodate all of these personnel to as high a degree as possible. In addition, since the prospective students differ in age and experience, the program must provide proper refresher material. Also, a selection of courses in basic electrical and chemical engineering is necessary in order that the students may acquire a somewhat common background.

The basic purpose of the studies is to prepare members of each of the major engineering disciplines for systems work in the chemical industry. All the students must therefore take a major in servo mechanisms concepts and in operational mathematics. However, because of their different backgrounds, other portions of the program must be tailored to fit each of the various different engineers and scientists involved.

Therefore, chemical and mechanical engineers will pursue a minor program which will seek to remedy their lack of a background in basic electrical engineering. Courses in electromagnetism, alternating current theory, and electronics thus seem indicated. Similarly, the minor program for electrical engineers will fill in their background with a study of the basic unit operations of chemical engineering and the physical and chemical phenomena involved in measurement methods.

In deciding the level at which to present the material, two considerations were taken into account: first, in order to interest properly qualified candidates, it seems necessary to offer them some substantial reward for their efforts; therefore, the possibility of attaining at least a master's degree was *necessary*. Second, the type of material to be presented is given at both the senior undergraduate and graduate levels at most engineering schools with the graduate level predominating. Therefore, the master's level was chosen for our program.

Our immediate objectives appeared to be most readily attainable through a program of considerable scope rather than one of the short intensive type. Several of these latter intensive programs in systems engineering are offered at colleges and universities about the country, as well as by several of the instrument makers. It was concluded that such programs are not suited to the average uninitiated engineer because of their necessary great speed of presentation and usual high mathematical level. Therefore, we felt that a more comprehensive approach, beginning with a review of basic concepts, would yield higher returns.

It is, of course, our hope that the universities will recognize the needs of the chemical industry for special training in systems engineering. Then within a few years they can be turning out students qualified to do this work for the chemical companies just as they are now turning out qualified systems engineers for the defense industries. At that time such special training courses as the above will no longer be necessary.

Developments and trends in process control in Europe

A. J. YOUNG, *Imperial Chemical*

It has been reported frequently by visitors to both Continents that "the best factory instrumentation in Europe is as good as the best in the U.S.A.," and that "both Europe and the U.S.A. must admit to having equally bad examples of process instrumentation." In principle, these remarks are true, but they ignore the obvious fact that during the postwar years a great deal of the most highly developed equipment available in Europe has been developed and designed in America and that it has not become available in Europe for some considerable time.

This is especially true of the potentiometer recorder, (whose servo-operated system provided the working force required for the operation of pneumatic control units), the three action controllers which followed and which have been continuously developed to their present high level of reliability, and the pneumatic transmission systems which made centralized control practicable for large and complex plants.

Probably the U.K. has used a greater proportion of U.S.A. developed process instruments than other European countries, which were not always as favorably placed to obtain them or which did not recognize the value of improving practice. Germany is a particularly outstanding example, and this is reflected in the reliance Germany industry placed on her own instrument industry and the production of a completely German range of measuring and control instruments. Nevertheless, as Otto Winkler has stated recently (*1*) in a report on German process control, the development of the pneumatic transmission system by the U.S.A. made possible considerable advances in German process instrumentation.

For examples of German developments, which were subsequently developed in other countries, particularly in France and in the U.K., it is only necessary to consider the analytical class of instruments, e. g., the infrared gas analyzer and the paramagnetic oxygen meter which were both in use in Germany at the end of the War. In the same class, the chromatograph was the result of British work.

continued

Trends in Europe

continued

In general, however, the pattern of development has run true to form: Europe is most successful in the conception and development of new principles of measurement, but less successful in designing and manufacturing the "plant-worthy" instrument. Fortunately this pattern, to which there have always been very notable exceptions of course, is rapidly becoming a thing of the past—as is evident from the new European equipment to be seen in factories and at the exhibitions.

The trend to be detected in this field is undoubtedly towards an increased rate of development of new types of equipment and towards greater concentration on perfecting their engineering design.

It is significant that the first all-electric, three-action process controller to be put on the market was made in the U.K., and that at the present time there are as many types of such controllers being made in Europe as in the U.S.A.

It appears from what has already been published in the U.S.A., and from the papers read at this Conference, that the developments European engineers wish to see in equipment are the same as those considered necessary in the U.S.A.

For example, it is recognized that it may be necessary in the future to use a computer as part of the control system of special plants or works, but there is a definite reaction from some experienced control engineers against any suggestion that the computer-controlled plant will be anything but a rarity.

While this view, which is reported by Otto Winkler as being held widely on the Continent and particularly in Germany *(1)*, does not exclude the possibility of using computers on the plant, it does militate against the development of suitable types of computer for the purpose and, of course, the development of new types of control system which would exploit them.

To balance this view, another school of thought (with which the author of this paper associates himself) is convinced that the computer (and in the less distant future probably the digital computer) has an important part to play, provided sufficiently reliable machines can be made for continuous process use.

The general objectives this school has in mind are, broadly:

1) The improved control of processes to give better consistency of product, in spite of inevitable disturbances.
2) The automatic optimization of operating conditions to give best yield and to make best use of available material and energy supplies.
3) To facilitate and quicken changeover to new operating conditions imposed on the process from outside.

These objectives are understood to be very much in line with the ideas of those who are working on this application for computers in the U.S.A., and no doubt for the same reasons. These need therefore not be restated, but there are a few important points to stress.

First, the interests of the oil industry and the chemical industry in close control of product quality are converging. This is because the oil industry appreciates that "blending" to maintain a product quality specification is a wasteful way of achieving it, and also because the manufacture of petrochemicals presents the quality problem of the chemical industry as a whole.

Second, the cost of "off-line" time for repairs or maintenance is becoming more and more important.

Third, there are two ways of looking at the problem: one is from the point of view of the individual plant, the second from that of a group of plants.

Fourth, the limit of process complexity has already been reached, it is thought, for manual control. It is to be expected that processes will be operated in future which cannot be operated by existing systems. There are few who do not agree that this is probable.

The merits of the case for the computer can be assessed only if the economics of process operation and particularly of control are themselves understood and expressible quantitatively. At present they are not, but a determined effort is being made by at least one group to remedy this situation.

Meanwhile, an important matter for a parallel investigation concerns the amount of information which is really vital for process operation. Experience indicates that only a small fraction of the information obtained by measurement on most processes is ultimately used. On the other hand, the measurements which are vital should be taken by more sensitive and in some cases (depending on the process characteristics) by more rapid instruments. Whether the measurements should be digitized at source, or not, and whether separate measuring points with analogue presentation should be used to monitor the process, particularly for drift, are matters for discussion.

One problem is however often overlooked, namely that of starting up the process, which will demand special facilities, and self-testing of the control system when it is being commissioned. These matters are being considered now, because they influence the nature of the computer to be designed eventually.

The part to be played by digital and analog computers in process and plant design (which cannot be divorced from control system design) is being appreciated in Europe *(2)*. Impetus was given to this work by the development of a method of interpretive programming for the Ferranti computers *(3)*, which is quickly learned by chemists and engineers with no programming experience. The importance of this lies in the facility it gives the man with a problem to program it for himself. This decreases the number of professional programmers required, and leaves the specialists to handle the difficult programming and to develop the application of the computers.

In the past European work in process control was mainly devoted to:

1) the analysis of automatic control equipment characteristics
2) the development of theoretical and experimental methods for the analysis of process dynamic characteristics
3) the development of practical methods for applying standard synthesis procedures for linear closed-loop systems to process control, using certain arbitrary performance criteria.

These objectives have, broadly speaking, been reached, although the work remains to be extended and refined. At the present time, as well as being preoccupied by process investigations to obtain their characteristics, research workers are considering the difficult question of designing non-linear systems. The fast computing facilities now available make this feasible, at least for specific cases.

Also, the time when it was sufficient to design for step disturbances has passed and it is necessary to explore the relationship between disturbance pattern and control quality and the criteria to be adopted. A paper on this subject will be published shortly *(4)*.

The most solid progress is however being made in process characteristic investigations, as indicated in the following.

The response to temperature changes in heat exchanger fluids has

been covered up to a point for simple exchangers. European work tends to be concentrated on response to flow changes. This is important because control is usually affected by changing the flow rate.

Work is also proceeding to extend the theory for temperature changes to more complicated exchangers (multipass, with baffles etc.) and to take account of the complications which are encountered on the full-scale factory plant.

Much more data are required on the steady state characteristics of heat exchangers. Quite new work in this field is being done, for example, on heat transfer when liquid metal is one of the working fluids *(5)*.

Some valuable results on agitation have been obtained by the work based on the concept of a constant diffusion coefficient throughout a mixing vessel *(6)*.

Similarity theory has been applied to the study of mixing in Germany *(7)*, and in Russia work has been published on theoretical and experimental studies of mixing in autoclaves *(7)*.

The considerable progress made in distillation by European groups is described in seven papers *(8)* published since 1956. It can be expected that another important paper *(9)* will be published before the end of 1958.

So far the published investigations have been confined to binary systems and to plate columns. Work is proceeding by some groups on packed columns and it is expected that once the binary system has been dealt with satisfactorily, the theory will be extended to multiple-component systems fairly readily.

Earlier work on the characteristics of reboilers *(10)* was of interest in that it demonstrated very clearly the dangers of using the "block diagram" approach to predicting process characteristics. It was shown that the only satisfactory method of setting up an analog of the system was to use the equations derived from fundamental principles to describe it.

It is important to note that the published work deals with response to concentration disturbances, whereas flow changes are also important. This is analogous to the position in the heat exchanger field, and work now proceeding is directed to remedying it.

The results of a semitechnical scale investigation, with a continuous flow of water through the autoclaves *(11)* have been extended to full-scale equipment for a polymer production. A paper will be published in due course to give the results of comparing the response predicted (using both digital and analog computers) and that determined experimentally. The paper *(12)* will include the results of another autoclave system, which involves a variable jacket side heat transfer coefficient.

A theoretical paper, describing an analog simulator for analyzing the dynamic behavior of boilers has been published in Belgium *(13)*.

The Cambridge Conference on Dynamic Characteristics is referred to because its proceedings, which have been published *(14)*, give a good indication of the European position at that time in this part of the development field. Progress has accelerated since then and a number of papers can be expected to deal with this subject during 1958.

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CHROMATOGRAPHIC ANALYZER For Determining Trace Hydrocarbons In Air Separation Plants

The success of an analyzer in preventing explosions in liquid air plants—a detailed engineering study.

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A. B. Alexander, Jr., R. W. Sauer
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Explosion hazards in liquid air plants have been attributed to the accumulation of hydrocarbons, particularly acetylene, in the air fractionating towers (*3, 5, 6, 7*). Trace amounts of acetylene are generally believed to provide the "trigger," and somewhat higher concentrations of other hydrocarbons the "fuel" in such explosions. Analysis for acetylene and other hydrocarbons in the liquid air to provide a basis for control is, therefore, of paramount importance. For this purpose a trace component gas chromatographic analyzer was developed and is in use at the ammonia plant control laboratory of the Atlantic Refining Company in Philadephia. In this plant by-product hydrogen from Catforming is combined with nitrogen separated from the atmosphere to produce ammonia (*1, 2*). The analyzer is used to monitor the hydrocarbon content of the liquid air in the rich air vaporizers as well as in the atmosphere surrounding the plant. Individual paraffinic and olefinic hydrocarbons ranging in molecular weight from C_2 to C_8, including acetylene, are being determined on a routine basis at concentrations ranging from

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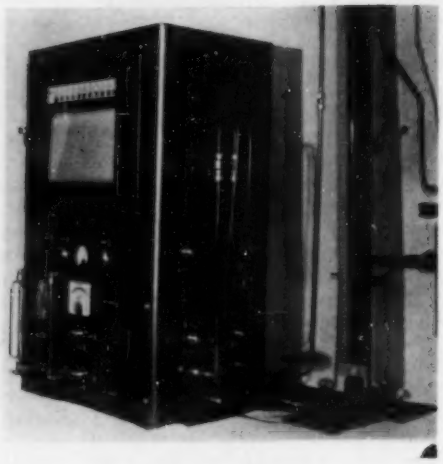

Figures 1 and 2. Illustrate equipment details of analyzer

Chromatographic analyzer

continued from previous page

less than 0.01 up to 40 p.p.m. in about one hour.

The analyzer is based on chromatographic techniques reported by Eggertsen and co-workers (*4*) of the Shell Development Company. The operating technique permits detection of hydrocarbon concentrations beyond the detectability range of presently available commercial instruments. Hydrocarbons are concentrated and separated from air by passing the sample through a packed U-tube immersed in liquid nitrogen. The trapped hydrocarbons are then flushed into a chromatographic column with helium carrier gas, where they are separated and then analyzed by passing through a thermal conductivity cell detector in the carrier gas stream. A permanent record of the analysis is obtained by transmitting electrical output from the detector cell to a strip chart recorder. Components of the sample are identified by their emergence times, and quantitatively determined by measuring peak heights or peak areas from the records obtained.

Three chromatographic columns, which may be operated at temperatures ranging from 0°C., or lower, up to about 175°C. are included in the analyzer. Any one of these columns may be selected for a given analysis by turning selector valves, and the columns can be readily changed to fit future needs.

The instrument has been used successfully by plant laboratory technicians for a period of five months.

Description of analyzer

The analyzer is housed in a steel cabinet proportioned for laboratory bench operation as shown by the photographs in Figures 1 and 2. Cabinet dimensions are approximately 23× 15×35 in., and the whole installation requires a bench surface area of about 3×2 ft. The unit consists of five major components:

1. Three chromatographic columns contained in two constant temperature baths with appropriate selector valves.
2. Detector
3. Recorder
4. Carrier gas manifold and sampling system
5. Electrical power and measuring circuits.

The chromatographic columns are ¼-in. O.D. copper tubing filled with suitable packing and maintained at constant temperature. One column is contained in an ice bath to the left of the cabinet while the other two are held in a heated bath inside the cabinet.

The detector is a model TR2B, 4-filament, Gow-Mac thermal conductivity cell. Capillary glass tubes, 150 mm. long × 0.7 mm. I.D., are connected to the exhaust from the reference and sample sides of the cell to provide a controlled pressure drop through the detector. The cell is operated with a current of 300 ma. and at a temperature of 210°F. A standard −0.05 to +1.05 mv. recorder measures detector output.

The carrier gas flow path (see Figure 3) provides concentration and introduction of the sample while maintaining regulated helium flow through the column and detector. A flow of 35 cc./min. is maintained through the sample side of the detector cell, and a flow of 5 cc./min. through the reference side. Carrier gas flow is controlled with needle valves and measured with rotameters. Helium supplied from a cylinder first passes through a U-tube immersed in liquid nitrogen to remove traces of hydrocarbons present as impurities. All manifold connections are sealed with Glyptal resin to prevent leaks, and Nordstrum No. 555 hydrocarbon insoluble grease is used to lubricate all analyzer valves.

The electrical system (Figure 4)

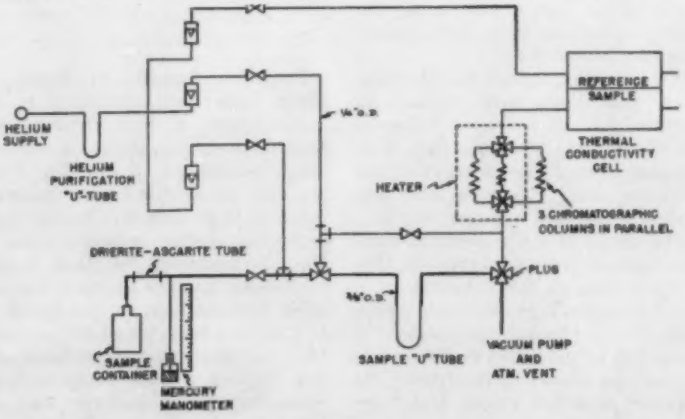

Figure 3. Analyzer flow diagram

consists of a measuring circuit and a 115-v. a.c. circuit which provides current for the recorder, column, and cell heaters. Manual temperature control of the heaters is used, since the sensitivity of the instrument is such that cycling heater control causes instability in the baseline of the chromatographic record. Current for the measuring circuit is supplied by two standard 12-v. automotive storage batteries which are alternated daily, so that one battery is being charged while the other is in use. Cell current is adjusted by means of a 25-ohm rheostat, while cell balance is accomplished by a system consisting of a 25-ohm potentiometer and a variable resistance shunted across the potentiometer to provide fine and coarse adjustments. The output from the cell can be attenuated in three steps: 100:1, 10:1 or 1:1 by means of a system of fixed resistances connected across the cell output terminals. Grounding of the cabinet and cell is essential for good instrument stability.

Sampling procedure

Either gaseous or liquid-air samples may be analyzed. Gas samples are obtained in evacuated sample bottles or Orsat tubes of known volume, and the bottles, filled with sample at atmospheric pressure, are attached to the sample inlet of the analyzer with a mercury manometer. The sample U-tube is immersed in liquid nitrogen and the sample bottle evacuated through the U-tube to a pressure of about 100 mm. Hg. For gas samples up to one liter in volume, residual sample is flushed from the sample bottle by alternately filling the partially evacuated bottles with helium from the manifold system followed by evacuating again through the sample U-tube. This procedure, which is carried out by turning the proper valves, is repeated twice. For samples larger than one liter, the volume of sample used is determined by calculation from the pressure remaining in the container.

Large samples of atmospheric air may be conveniently collected by immersing a sample bulb, Figure 5, in liquid nitrogen. Atmospheric air is drawn by condensation through the stopcock into the sample bulb at a rate of about 1.2 ml. of liquid or 1 liter of gas/min. Measured amounts of liquid sample also may be taken directly from the air plant into the sample bulb, which is immersed in liquid air of the same composition as the sample. When the Dewar flask is kept filled with liquid air, samples may be stored for several hours without a significant loss in volume. The sample bulb is attached with Tygon tubing to the sample line on the analyzer while still immersed in liquid air, and evacuation through the sample U-tube, which is immersed in liquid nitrogen, is begun. The Dewar flask around the sample bulb is then replaced by a glass tube wrapped with aluminum foil, precooled by filling to about 25 ml. with liquid nitrogen. Pumping is continued at a controlled rate so that a 25-ml. liquid air sample is completely evaporated in a minimum of 20 min., and to a pressure of 30 to 60 mm. Hg. If pressure surges occur during the evaporation, a small amount of liquid nitrogen is poured into the tube around the sample holder. Residual gas sample is flushed from the sample holder by alternately filling with helium and evacuating. This flushing step is repeated twice, and the sample U-tube is purged to the atmosphere for 3 min., with helium at a rate of 800 cc./min. to remove excess air. The helium flow rate is then adjusted to 35 cc./min., the flow through the U-tube directed to the desired analytical column, and liquid nitrogen around the U-tube is replaced with a suitable heating bath to desorb the sample. For C_5 and lighter hydrocarbons an ice bath is used for desorbing sample.

Calibration and analysis for C_5, lighter hydrocarbons

The column used for determining

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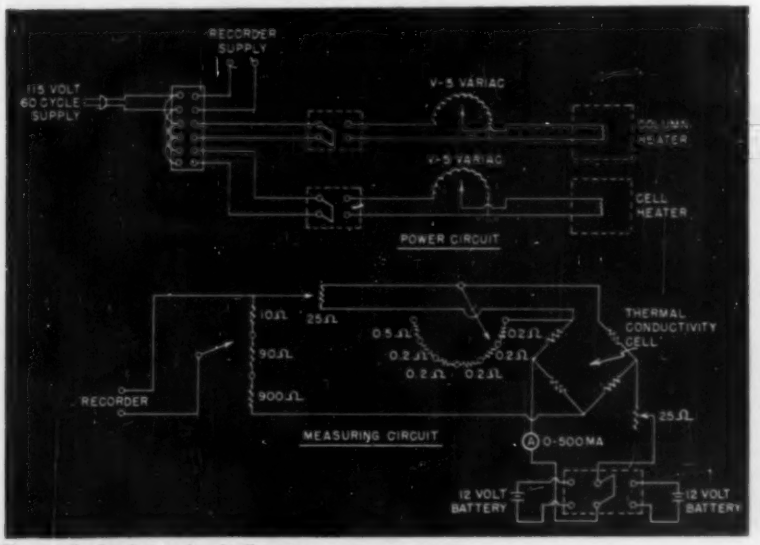

Figure 4. Analyzer circuit diagram

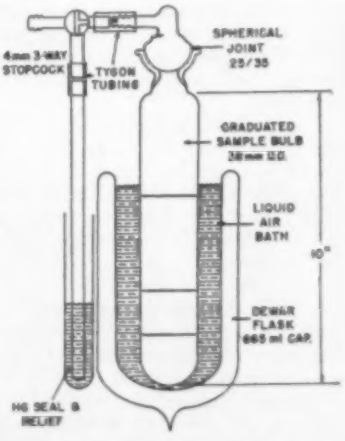

Figure 5. Sampling apparatus

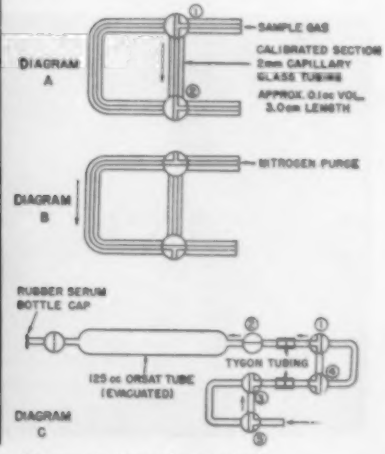

Figure 6. Use of gas pipets

Chromatograph analyzer

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C_5 and lighter hydrocarbons is a 25-ft length of ¼-in. O.D. copper tubing packed with 20-60 mesh C-22 firebrick (Columpak, Fisher Scientific Company) and impregnated with 20% by weight of 2, 4-dimethylsulfolane (Shell Chemical). The sorbent is packed into the column with a vibrator to a density of 3.4 g./ft. of column tubing. The column is coiled to fit into an ice bath contained in a 2-liter Dewar flask, and coupled to the analyzer with tubing unions. The sample U-tube and helium purifying U-tube are both packed with 6-in. of the same sorbent. In addition, a 15-in. length of ¼-in. O.D. copper tubing is inserted in the sample train, packed one half with Drierite and one half with Ascarite as shown in Figure 3, to remove water and carbon dioxide from the sample. Carbon dioxide must be removed since it has the same retention time as propane. During continuous operation the Drierite and Ascarite are replaced each week.

For simplicity in rapid routine analysis of ammonia plant samples peak heights are used for determining concentration. Calibration is made with known mixtures containing propane and acetylene. The calibration curve for propane is used in calculating analyses for components with retention times through *n*-butane, and the acetylene curve is used for acetylene and other components with retention times through *n*-pentane.

Known mixtures of acetylene and propane are prepared by using calibrated gas pipets as shown in Figure 6. The pipets, about 0.1 cc. in volume are calibrated by weighing mercury required to fill the calibrated section. One pipet is filled with acetylene and the other with propane, (diagram *A*, Figure 6), by flowing gas for one minute at a rate of about 100 cc./min. through the calibrated section. The stopcocks are then turned to the positions shown in diagram *B* to trap gas in the calibrated section at 1 atm. pressure, and the stopcocks are purged with nitrogen or air. The pipets are connected with Tygon tubing to an evacuated 125-cc. Orsat tube equipped at one end with a rubber serum bottle cap. Hydrocarbon free air is then allowed to flush the measured volumes of gas from the pipets into the Orsat tube to a pressure of one atmosphere by turning the stopcocks in the order shown in diagram *C*. Stopcock 2 is closed and the pipets disconnected. The gases in the Orsat tube are mixed by expanding and compressing with a 25-cc. hypodermic syringe inserted through the serum bottle cap. Aliquots of 1.0, 3.0, 5.0, and 10.0 cc. of this standard hydrocarbon mixture are then transferred by means of hypodermic syringes to other clean, evacuated 125-cc. Orsat tubes. The Orsat tubes are then connected separately to the analyzer sample line, and the known volumes of hydrocarbons flushed into the sample U-tube, as previously described, to obtain calibration curves in parts per million by volume as shown (Figure 7). Nordstrum No. 555 valve grease is used to lubricate the stopcocks, and starch-glycerine lubricant is used on the syringes.

In calculating analyses the concentration obtained from the calibration curve is multiplied by the appropriate sensitivity factor X1, X10, or X100, depending on the analyzer sensitivity setting used to keep the component peaks on scale.

Apparent retention times and relative retention volumes for C_5 and lighter hydrocarbons are given in Table 1, and a typical chromatographic record for a 25-ml. liquid-air sample from the plant rich air vaporizers is shown in Figure 8. Sensitivity changes made during the analysis are indicated on the record.

Table 1. Retention Values of Hydrocarbons

Subtrate: 2, 4-dimethylsulfolane
Temperature: O°C.
Carrier: Helium at 35cc./min.

	Apparent retention time (min.)*	Relative retention volume
(Air)	(14.5)	....
Ethane	1.7	0.33
Ethylene	3.3	0.64
Propane	5.1	1.00
Propylene	9.3	1.81
i-Butane	10.8	2.12
n-Butane	17.3	3.39
Acetylene	24.0	4.71
Butene-1	29.4	5.76
Isobutylene	31.8	6.23
Isopentane & *trans*-Butene-2	39.8	7.81
cis-Butene-2	47.7	9.36
n-Pentane	51.7	10.01

* Measured from the air peak

Table 2 shows a comparison of analyses of a liquid air sample by this method and that of Quiram and Biller (8). The latter method involves concentration of hydrocarbons in a high vacuum manifold and subsequent analysis by mass spectrometer.

Operation

The Atlantic instrument was intended for routine use in the ammonia plant control laboratory. Early in the design stage the complete set up was "breadboarded" to check the opera-

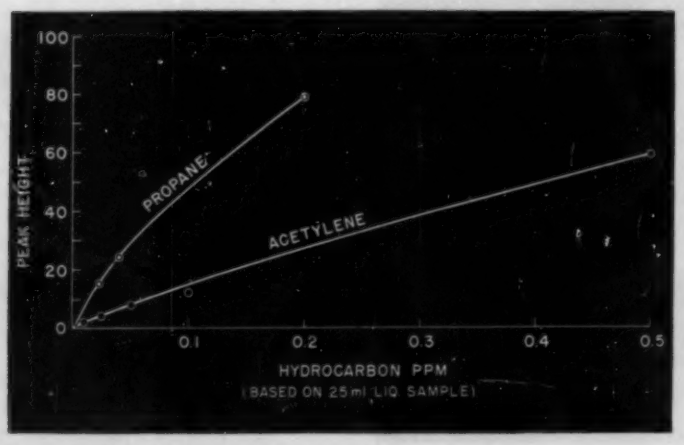

Figure 7. Chromatograph calibration (p.p.m.)

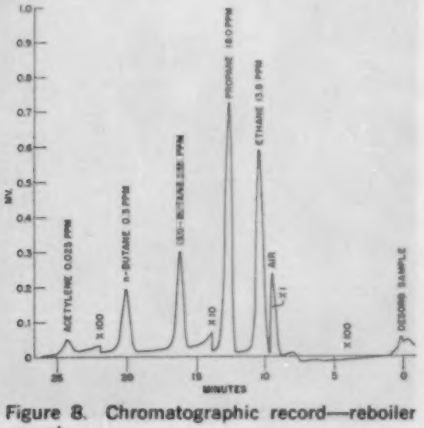

Figure 8. Chromatographic record—reboiler sample

tion of the various components prior to construction. This procedure eliminated changes in the final unit.

Upon completion the instrument was tested and calibrated by technical personnel in the Research and Development Department. During this period, training in operation and maintenance of the unit was given to the plant laboratory technicians. In the plant the instrument was mounted on a laboratory bench on a sheet of sponge rubber to minimize vibration.

During the first two weeks of plant use, a minimum of technical help was required to overcome problems associated with plant operation. Some additional training in maintenance and operation was given the plant technicians on the site. Since its installation in December, 1957, the instrument has been operating on a satisfactory, routine basis, with all preventive maintenance in the hands of ammonia plant laboratory personnel and plant instrument mechanics.

Other Applications

By proper selection of column packing and operating temperature the analyzer may be used for the analysis of other trace components. For example, higher boiling hydrocarbons up to about C_{12} in molecular weight can be determined by using columns operating at temperatures up to 150 or 180°C. Inorganic gases such as nitrogen, oxygen, and carbon monoxide might also be determined by using molecular sieves (Linde 5A) at temperatures ranging from room temperature to 100°C. For each specific application calibration is first obtained with known mixtures, and special consideration must be given to the nature of the sample U-tube required to separate the bulk of the sample from the trace components.

ACKNOWLEDGMENT

The authors wish to acknowledge the assistance of others in the Manufacturing and R & D Departments of the Atlantic Refining Company who have contributed to the success of this installation.

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process control

Application of DIGITAL SYSTEMS to process control

The economics, planning, installation, and necessary control mathematics of digital control systems for chemical process plants.

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The past five years have seen the widespread development and use of electronic digital computers in scientific and business applications. In the next five to ten years, it seems likely that similar computers will be widely used in the control of industrial processes and activities. A digital control system of this kind may be briefly described as a digital computer connected directly to process instruments. The computer is able automatically to read process variables, make computations based on those variables, print out whatever information may be desired about the process, and make adjustments directly on the process to ensure its best operation. The actions to be taken by such a computer control system must be specified in complete detail so that a program of instructions may be devised and inserted in the computer memory. The control system can do no more than it is told to do by this program, though the program can be changed very easily and quickly without the need for additional equipment.

Economics

The cost of a digital control system is, and will for some time continue to be, higher than the cost of more conventional control systems. A typical system, complete with instrumentation, may cost from $200,000 to $500,000 installed. In addition, both before and after installation, such a system requires the time and attention of experienced process engineers if it is to be used effectively and is to contribute the largest possible benefit to the company purchasing it. But this large expenditure can be rewarded by ample returns arising from better process control and supervision. Where the market for a product is unsaturated, a digital control system can contribute improvements in process yield, conversion, or chemical efficiency which will easily pay the cost of the system. In this connection, it must be remembered that for a large and complex process, producing a valuable product, even a very small percentage increase or improvement in operation may justify a quarter of a million dollar investment.

A second type of benefit comes about through reduced costs of operation. Costs may be reduced through the more effective use of the catalyst, through the reduction of fuel costs, through the more efficient use of steam or cooling water, and through reduced maintenance costs. Maintenance costs may be particularly important if the computer control system can slow down fouling of the equipment, or can anticipate instabilities or hazardous conditions which may cause the process to be shut down for repairs.

The final area of improvement comes about through the improved quality arising out of better control. In some processes, product quality is of no importance and it is almost impossible to make an off-specification material. In others, quality is a parameter that may require a delicate balance among various control conditions. Under these circumstances, the

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success of a process may depend entirely on the operator's ability to control quality satisfactorily.

Generally speaking, some balance is required among the three factors: production, costs, and quality. The objective of control may be that of producing the maximum amount of a product of a certain quality, or, if the market is saturated, of producing a given average amount at the specified quality with the lowest possible operating costs. It is particularly important and interesting to note that the proper conditions of operation depend very much on current market conditions, and can change substantially from one month to the next.

Figure 1. Characteristics of a typical arbitrary process.

Planning an installation

A number of challenging technical problems must be solved before a digital control system can be installed and made to work in a refinery or chemical plant. The choice of a process suitable for control by a digital control system is dependent on a wide variety of factors. Two of these are of utmost importance.

The first is economic. The approximate cost of a control system is likely to be, say, $250,000, and it will be of no use to try to apply such an expensive system to the control of a debutanizing tower, for example, having a capacity of 1000 barrels per day. It is necessary to find a process where there is a large throughput and an appreciable increase in product value over raw material cost, and where there is a substantial difference between the present level of operating efficiency and the maximum theoretical efficiency.

In addition to this economic factor, there is, of course, a second technical one. Perhaps the most important technical factor is the availability of adequate data about the process, preferably from past records on operation of the process to which the control system is to be added, but alternatively from records on other similar plants employing the same process. This data will be used in the development of suitable control equations.

When the process has been chosen, the first step is the development of equations which determine what the computer is to do. This is the most difficult step in planning a digital control system. *It is so important that the latter half of this paper will be concerned with it.*

When the major control equations have been decided upon, it is necessary to specify what auxiliary functions the computer control system will be required to perform. One very important function is that of logging pertinent quantities related to process operation. These quantities may be simple instrument readings, or may be more complicated functions of these readings, such as catalyst activities, heat exchanger coefficients, yields, conversions, etc. The computer may also be required to sample certain signals periodically in order to compute averages over a period of an hour or longer, or in order to accumulate total flows over a period of a day.

A final class of computer functions is conducting checks and tests on the process and on the process instruments to detect instrument failures, and to look for process instabilities or for hazardous conditions. These tests may include the simple checking of upper and lower limits, which is accomplished by an ordinary logger. They may also include more powerful checks involving the relationships between a variety of different instrument readings. For example, it may be desirable to carry out a material balance periodically as a means of detecting unusual conditions.

When the functions of the control system have been determined, it is necessary to choose a set of instruments which will make it possible to measure all pertinent process variables needed in the control and other calculations. Many of the measurements necessary can be made with sufficient accuracy using conventional instruments. Certain others may require the use of new or fairly new continuous analytical instruments. Finally, there are usually a small number of variables which cannot be directly measured with any degree of reliability using process instruments available today. It still may be possible, however, to get along without a direct and continuous analytical instrument. One way around this difficulty is to find some indirect method of measuring the variable. In some instances, one may find some other variable which can be measured and which varies in some way related to the variation of the primary variable. For example, a temperature rise or drop in a reactor may give a measure of the amount of material reacted and therefore of the composition of the product. Or a physical parameter such as viscosity or color may be directly related to a chemical property. As a last resort, it may be possible to get infrequent laboratory analyses of the variable under discussion, and to introduce these into the computer through its digital input system. Such laboratory analyses may be available only at widely separated time intervals, but if the variable involved changes slowly enough, the computer can be made to extrapolate between analyses.

When suitable instruments have been chosen and the control system functions have been clearly defined, it is possible to plan the program which the computer is to carry out, and to procure and install the required instrumentation and the specific instrument input-output system which must be supplied with the computer.

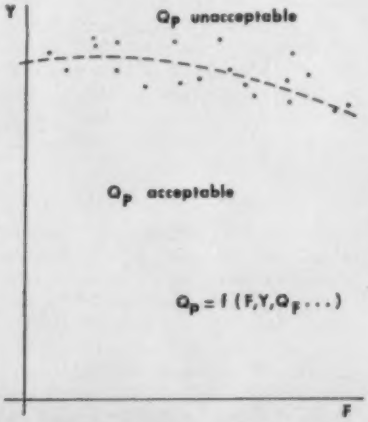

Figure 2. Relationship between product quality, feed flow rate, process yield, feed quality, etc.

Developing control equations

In order to make this method of development clear, and to avoid talking wholly in generalities, it will be convenient to describe the characteristics of a typical but anonymous process.

Process description. The chief characteristics of the anonymous process are indicated in Fig. 1. A raw material is supplied to the process at feed rate F. This feed has a characteristic (a chemical constituent or a physical property) which is measured by some quality parameter known as Q_F. The process itself is characterized by a yield, Y, which is a function of the feed rate, the feed quality, and of the various process parameters which can be controlled by the operator—the temperatures, pressures, flows, liquid levels, etc. within the process which deter-

mine the course of the chemical reactions or physical processes inside the rectangle of Fig. 1. The major product of the reaction thus appears at flow rate FY at the output of the process. (There are, of course, other products of the reaction not shown in Fig. 1. We need not be concerned with them for purposes of this description). The character of the product is specified by some other physical or chemical parameter known as Q_P, and is in general some function of the feed flow rate, the feed quality, the process yield, and the operating temperatures, pressures, levels, and flows within the process. It should be recognized, of course, that in general a process may have several different and independent parameters such as Q_F over which the operator has no control, and that product quality may be measured by several different and independent parameters like Q_P.

The general control problem can now be stated. *It is the function of any control system to operate the process so as to manufacture at maximum profit a product having a certain minimum quality as measured by Q_P in the face of fluctuations in feed quality characteristic Q_F (and other independent variations over which the operator has no control), by making adjustments in flows, temperatures, pressures, etc. within the process over which the operator has direct control.*

Objective. The first step in setting up the control equations for a process is to write an equation expressing the process objective. In the final analysis, this objective is always economic. That is, one is trying to operate the process in order to derive from it the maximum return on the initial investment in that process. The dollar return, D, obtained from operating this process may be expressed by subtracting the cost of raw materials and the cost of operating the process from the values of the products of the process. In simplified form, this equation is

$$D = K_1FY - K_2F \qquad (1)$$

In this equation K_1 includes the value of the product less the operating costs proportional to the amount of product made, and K_2 includes the cost of the raw material plus the operating costs proportional to the amount of raw material used. The various operating costs which remain constant regardless of how the process is operated need not concern us in this analysis, and will not have any effect on normal process operation. In order to write equation 1 it is necessary to make assumptions about the value of the feed to the process and of the product or products obtained from the process. If the process of Fig. 1 is some intermediate process in a large plant, this may be a difficult thing to do, for the values of materials may depend very much on other operations in the plant, upon the rates at which the feed is used and the product is produced, and upon plant raw material characteristics and general market considerations. For the purpose of controlling the process of Fig. 1, however, it must be assumed that the larger problem of best control for the whole plant has been solved, and that a proper set of coefficients K_1 and K_2 for equation 1 can be supplied.

Equation 1 incorporates one major process simplification: it is time-invariant, and all process dynamic considerations have been left out of it. In the actual process, Q_F is continually varying to some extent, and the operator is frequently making adjustments to the input flow and to process conditions so that the product flow rate at any given time is a function of not just one flow rate F and one yield Y but rather of a combination of varying flow rates and yields. Our approach, however, will be to assume that the process is made to change smoothly from one steady-state condition to another, where for each steady-state condition one value of Q_F, and F, Y, and Q_P holds. If adjustments are made in the process at the proper rate, then this steady-state approximation will be close to the true dynamic description of the process. We will therefore derive time-invariant equations for the process description, and will then examine this description carefully to see what

Figure 3. A graphical solution to control equations.

effect process dynamics has on it, and how frequently control adjustments should be made. The objective of operating the process is that of operating it so that the "operating profit" D is a maximum. It must be recognized, of course, that a procedure which makes D a maximum instantaneously from minute to minute and hour to hour may not yield as high a total profit over a period of time as some other procedure would. For example, operation which maximizes instantaneous D may be that which causes a catalyst to deactivate very rapidly, with the result that an expensive catalyst replacement or catalyst regeneration becomes necessary and reduces the net "operating profit." We will assume that no such conditions exist in this process. If such conditions do exist, special steps must be taken to handle them. (1)

Constraints. Once the economic objective has been established, it is necessary to go over the process in some detail to list the constraints or restrictions on process operation which are dictated by equipment limitations, reaction conditions, safety considerations, product specifications, etc. For the process of Fig. 1, let us assume that several such constraints exist. First of all, the feed flow rate F is limited by the capacity of a pump somewhere in the process so that:

$$F \leq F_{max} \qquad (2).$$

Next, market conditions are such that product quality must meet some minimum specifications. This may be written in the form of the inequality:

$$Q_P \geq K_3 \qquad (3).$$

Finally, the various control parameters within the process may have restrictions upon them. For example, some vessel may be so constructed that the pressure within it must be held below some maximum value; and perhaps a reaction temperature must exceed some minimum value in order that any reaction at all take place. These restrictions are:

$$\begin{matrix} \pi \leq \pi_{max} \\ T \geq T_{min} \end{matrix} \qquad (4).$$

There may, of course, be other constraints and restrictions upon the process.

Relationship between variables. It is now necessary to determine the effect which the variables appearing

continued on next page

DIGITAL SYSTEMS

continued

in the above equations have upon one another. The number of equations required depends upon the number of variables which have been defined and upon the degrees of freedom existing in the process. The form of these equations, too, depends on the definitions of variables and also upon the reactions and processes which go on inside the rectangle of Fig. 1. Material and energy balances may be among the relationships required. However, in general, it is necessary to express mathematically the effect of raw material characteristics and of process operating conditions upon yields, conversions, efficiencies, catalyst degeneration, product quality, and other dependent variables. This is, generally speaking, the most difficult part of the job of developing control equations. It must be tackled by a wide variety of different approaches, and many sources of data can and should be brought to bear upon this problem. The principal source is, of course, past data about the operation of the process. These data can usually be supplemented, however, by data collected from pilot plants, from other plants having similar characteristics, from published literature and information about the process, from patents relating to the process, and from data supplied by the licensor of the process. The data should also, where possible, be augmented by a mathematical analysis of the process—an analysis that takes process kinetics into account, for example, and requires the solution of a set of differential equations describing the process. The results of this analysis may establish the form equations should have to best represent process operation, and the coefficients used in these equations can be determined by matching them to operating data.

Let us assume that, for the process of Fig. 1, we are trying to establish the relationship between product quality, feed flow rate, process yield, feed quality, and operating temperatures, pressures, etc. Fig. 2 represents a typical situation. Here the dots represent data points accumulated over a period of time on a process. Each dot represents a reading taken when product quality was exactly equal to K_2, the minimum acceptable quality; feed quality was equal to some specified quantity Q_{F_2}; and process temperatures and pressures were fixed at some specific values. For these conditions there existed different values of feed flow and yield. The dashed curve shown in Fig. 2 is the curve which best fits this set of data. It is unfortunately typical of complex processes that a number of factors combine to make it impossible to account precisely for all the conditions which influence product quality, yield, etc. The spread of these points about the dotted line is accounted for by the fact that measurements are typically inaccurate, and are taken at nonrelated times, and that some variables which are not measured or taken into account influence these relationships.

The fact that the equations which can be developed in practice do not completely describe the process nor explain all of its characteristics does not mean that the equations are not useful. On the contrary, they represent the best possible information now available about the process and, if they are used in control, they will make possible closer control than can possibly be attained if only qualitative use is made of what is known about the process.

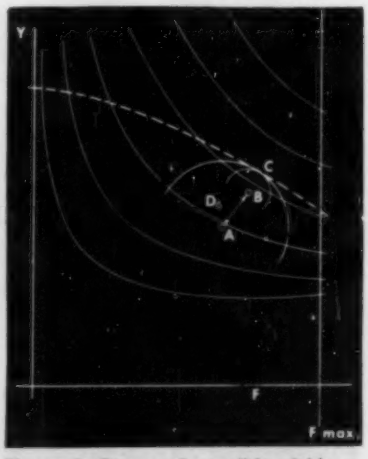

Figure 4. Range of possible yields.

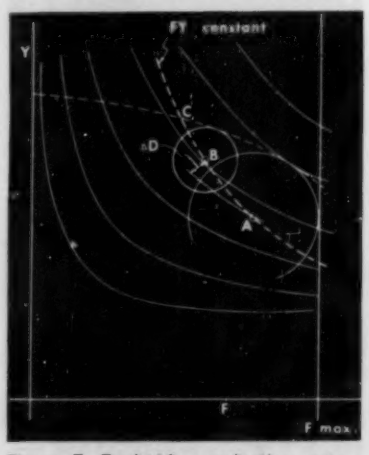

Figure 5. Desirable production rate.

Let us assume, then, that by use of the curve fitting and other techniques indicated above it is possible to express product quality as a function of the various operating variables, and it is similarly possible to find an expression for product yield as a function of these same variables. These two equations can be expressed functionally as:

$$Q_P = f(F, Y, Q_F, \pi, T, \ldots) \quad (5)$$

$$Y = g(F, Q_F, \pi, T, \ldots) \quad (6)$$

Assuming that these relationships are all that is necessary to characterize the process, we have completed the job of developing control equations.

Solution to control equations. We now have available all the information necessary to determine how the plant should be run. A graphical solution to these control equations is indicated in Fig. 3, where a number of curves are plotted on the FY plane. The solid hyperbolas represent plots of equation 1, where each curve represents a line of constant operating return. Those curves on the right represent larger values of D. If D is to be maximized, it is obviously desirable to operate in the upper right-hand side of this figure.

The vertical line at the right of the diagram represents the restriction of equation 2. Because of the pump limitation, it is impossible to operate at a feed greater than F_{max}. To make D large, then, it is evidently desirable to operate at feed=F_{max} and at as high a yield as possible.

The restriction on product quality, as shown in equation 3, must now be taken into account. In Fig. 2 we plotted a curve $Q_P=K_2$ on the FY plane, with feed quality equal to some value Q_{F_2}. We further indicated on that figure that operation with flows and yields such that operating conditions were below that line would result in a product which met the quality specifications, while operation above that line would result in a product which did not meet the specifications. In Fig. 3 the dotted curve of Fig. 2 is repeated, as are also a number of other dotted curves representing plots of equation 5 with different values of feed quality Q_F. In each case, it is necessary to operate below the appropriate dotted line if a product of acceptable quality is to be made.

We can now see what the conditions for best process operation should be. If we measure feed quality Q_F, we specify a dotted line of Fig. 3. We are then constrained to operate below or on that dotted line and to the left of or on the vertical line representing maximum feed flow. We must therefore choose, for each value

of Q_F, the point which lies in that restricted area and has D a maximum. When feed quality Q_F is better than Q_{F2}, it is clearly desirable to operate at maximum feed rate. However, if feed quality is equal to Q_{F2} or worse, a better D will be obtained if the feed rate is reduced. The peculiar solid curve of Fig. 3 indicates approximately the best operating point in the FY plane for different values of feed quality.

It is now possible to see how a proposed control system might operate. Periodic measurements should be taken of feed quality Q_F. Any change in Q_F will result in an adjustment, in general, in Y and F as indicated by the solution in Fig. 3. A computer system can determine the appropriate value of F, and can determine from equation 6 (and other related equations, in a practical system) how the various temperatures, pressures, and other operating parameters should be adjusted to obtain that yield at that flow.

At this point it is necessary to examine carefully the dynamics of the process to determine how frequently measurements should be taken on Q_F, and how frequently adjustments should be made in the various process parameters. Typically, the computer will be used to adjust or trim the set-points of conventional pneumatic or electronic controllers, and care must be taken that sudden adjustments of these set-points or combinations of these set-points do not introduce damaging or hazardous transients in the process. The computer can, of course, be made to carry out adjustments slowly over a period of time rather than in step fashion.

The control problem as described here is so simple that it probably would not be appropriate to install a digital control system to handle it. The computations involved could probably be done once and for all, and set up in tabular form for an operator to carry out. However, in general, the control problem is not this simple. There may be a large number of independent variables similar to Q_F which all together determine optimum operating conditions, and if there are enough of these it will not be practical to set up a tabular solution for an operator to follow. In addition, the computer can be employed to modify the control equations in the light of data gathered about the process. For example, it can measure yield, feed rate, and other parameters, accumulate data points similar to those in Fig. 2, and slightly modify the equation for product quality (equation 5) to make that equation represent as nearly as possible the most recent history of operation of the process.

Possible payoff for a digital control system

In conclusion, it might be worthwhile to discuss the payoff possible through digital control in the context of the example we have been discussing. Referring to Fig. 4, we have again plotted lines of constant operating profit on FY plane. The dashed line in Fig. 4 represents the product quality constraint for some specific feed quality, and the point of best operation is indicated by the letter C on that line. Typical conventional automatic control of the process is likely to be at a point such as A in Fig. 4, removed some distance from optimum operation. It will be some distance from optimum operation for several reasons. In the first place, the operator does not of course know precisely where the best operating point is. However, even if he did know, he would tend to operate some distance from it so that he would not have to constantly survey the process and make adjustments to keep product quality in bounds. He thus produces a product having appreciably better average quality than is necessary so that fluctuations in process characteristics which make substantial changes in product quality will not force him to make an unsatisfactory product.

A computer control system, on the other hand, will be able to operate appreciably closer to the optimum as shown by point B. It can be operated closer both because it can accurately compute where the best operating point is and also because it is better able to maintain a continual surveillance of all process conditions. It would, however, not be appropriate for the computer control system to try to operate the process at what it calculated was the optimum point, C, for several reasons. Most important is the fact that the equations which are used in control are only approximate and admittedly do not account for all variables which influence product quality. Furthermore, some allowance must be made for the fact that process measuring instruments are not wholly accurate. Finally, it is necessary to remember that very sudden changes in feed quality Q_F may occur, which are not anticipated by and cannot be immediately followed by the control system, and that a safety factor must be put in to allow for this possibility. Nevertheless, the difference in dollars between points A and B may be quite substantial and, when integrated over a period of a year, amounts to a substantial payoff.

One interesting feature of a digital control system is its great flexibility, and this flexibility can perhaps be well illustrated by showing how control would be exercised if a new constraint were added to the process description. Suppose that market conditions changed so that it was not possible to sell all of the product obtained from the process of Fig. 1. Suppose, in fact, that some specified production rate must be maintained, and the control system objective is to make the highest possible dollar return while operating at that production rate. In Fig. 5 we have plotted a heavy dashed line which represents this desirable production rate. Examination of this figure will disclose that the best operating point is the intersection of that heavy dashed line with the dashed line for minimum product quality at the given feed quality. For the same reasons expressed above, conventional automatic control will require that the operator back the process away from the best operating point to point A, and a computer control system might be able to operate at point B, closer to but still not at the optimum. Again, a substantial improvement in dollar return is possible. The important thing to note here is that the equations solved by the computer can be easily altered to meet changes in market conditions, or for that matter changes in the process itself or changes in the process engineer's understanding of the process. This flexibility allows the control system to grow and change as the process changes without any additional capital expenditure. The only modification necessary is a change in the program stored within the computer memory.

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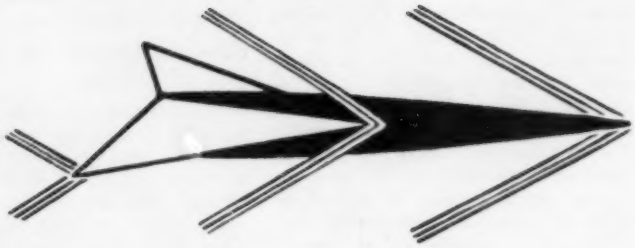
High temperature environments associated with jet propulsion



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General concern over the role of materials engineering for high-temperature applications has increased rapidly in the past few years. In particular, recent events have focused attention on the urgency of solving many problems, including those of materials, associated with the design and development of a variety of new types of high-speed flight vehicles. In these circumstances it is significant that high temperature has become one of the most pressing of the technical problems to be resolved. Fortunately, there is an extensive background of materials engineering experience that has been accumulated with respect to high-temperature materials service. This background provides an excellent guide to approach some of the new problems. Detailed knowledge of the environments to which materials will be subjected during service is one basic need that past experience has emphasized.

This paper brings into perspective the broad scope of high-temperature environmental conditions that designers of airframes and propulsion systems must contend with in achieving supersonic and hypersonic flight speeds. No attempt will be made to treat the many specialized aspects of the problem in detail. The current literature covering these specialties is voluminous and progress being made in understanding the physical phenomena is so rapid that concepts are being revised almost daily. Nevertheless, there are certain basic characteristics of the high-temperature problem that can be identified as of major importance. One of the most important of these characteristics is that high temperature in itself is not the all-important consideration in design. Instead, there is a wide range of combinations of environmental conditions related to high temperature. The complex nature of the problems results from the great numbers of variables to be accounted for, and from the greatly extended extremes of environment that are involved.

Basic environmental variables

Figure 1 shows the five environmental variables that must be taken into account when selecting materials for airframe and propulsion system applications. Each of these variables, temperaure, heat flux, duration of exposure, chemistry, and force is in turn a complex function of many other variables. Furthermore, for many of the new regions of flight, the five variables undergo rather rapid change. The transients involved are both a problem, and a salvation. The salvation arises from the fact that the environmental extremes encountered are often of such short duration that the resultant effect on materials is substantially minimized. The problem arises from the difficulty of *exactly* simulating the environmental transients in the laboratory, under conditions where material response can be observed.

None of the five variables illustrated is new or unique in itself to design and materials engineers. Unusual combinations of these variables are new, however, particularly the role of chemistry in combination with temperature and high rates of heat transfer. These new environmental combinations have in turn aroused interest in materials properties of both old and, in a manner of speaking, new structural engineering materials such as tantalum and graphite. The reasons for this new interest, and the skill that will be required (within the basic physical limitations of materials properties) will be illustrated in the discussion of typical operating conditions for airframes and propulsion systems that follows.

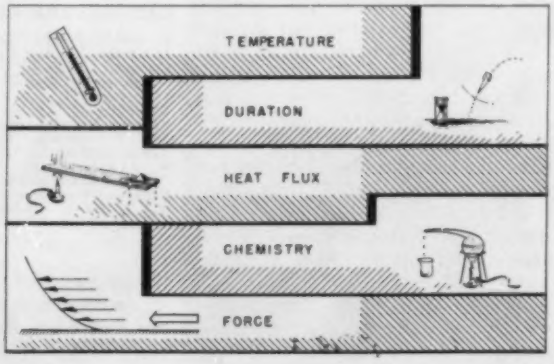

Figure 1. Basic environmental variables from the materials standpoint

Typical temperatures

Figure 2 illustrates several typical temperature extremes that components of high-speed flight vehicles may be subjected to during some portion of their service life. Also shown for comparison are approximate working temperature limits of some commonly available materials.

The important fact about Figure 2 is not the temperature values shown or the particular components selected.

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High temperature has become one of the most pressing of the technical problems to be resolved in the design and development of fuels and materials of construction of high-speed flight vehicles. What factors contribute to the problem, and what possible solutions the chemical engineer can devise are the subjects of this up-to-the-minute treatment.

Rather, the emphasis is on the fact that the high-temperature problem facing aeronautical engineers extends over a wide range of values ranging from a modest few hundred degrees to many millions of degrees Fahrenheit. The examples selected represent a good cross section of typical problem areas, and show, when compared with the materials temperatures presented, why there is concern and interest in the high-temperature characteristics of materials and in long overlooked structural materials such as graphite.

Hydraulic fluids and seals capable of withstanding temperatures in excess of 400° F. are an example of a "high-temperature" problem that presents a formidable challenge to chemists. Likewise, the research for lightweight replacements for aluminum in aircraft applications when temperatures approach 1,000° F. presently occupies the efforts of many metallurgists. The ultimate challenge becomes apparent, however, when one observes that most of the temperatures shown on Figure 2 exceed 1,600° F., a representative value of the state-of-the-art in high-temperature alloys for sustained exposure under high stress. This state-of-the-art has evolved gradually over many years starting with high-pressure steam boilers, and has been primarily directed in recent years toward nozzle vane and turbine bucket applications in aircraft gas turbines. Hence, the need for development of the refractory materials to a point of every-day structural use, and to evolve protection techniques for even these materials is apparent if equilibrium between the materials and their imposed temperature environment is to be required in the future. Fortunately, as pointed out earlier, other factors such as duration of exposure and rates of heat transfer enter into the picture. The favorable and unfavorable aspects of these other factors must be considered in terms of specific airframe and propulsion systems.

Aerodynamic heating

The high-temperature technology of greatest interest to aeronautical engineers at present is design of airframes capable of withstanding aerodynamic heating, which arises from the conversion of the kinetic energy of a flight vehicle into increased enthalpy of the air immediately surrounding the vehicle. Substantial progress has been made in reaching an understanding of the gas dynamics associated with supersonic and hypersonic gas flows, although there continues to exist a great need for further extensive research on many detailed aspects of the problem. On the basis of the current state of knowledge, it is possible to generalize on the nature of the aerodynamic heating effect on vehicles flying at altitudes of less than 300,000 ft. above the earth's surface. At such altitudes the mean free paths of the air molecules are sufficiently small that the laws of continuum flow apply.

Figure 3 illustrates four types of flight vehicles of current interest. These represent different combinations of variables that must be provided for by airframe designers. The values of the variables shown for each vehicle are merely order-of-magnitude numbers useful primarily for comparison. For each vehicle, reasonable assumptions with regard to flight profile, altitude, surface temperature, and boundary layer conditions have been made. The maximum heating rates shown are for stagnation points on the vehicles and thus would be more severe rather than typical for all exposed surface areas.

The cruise-type, air-breathing engine-powered aircraft at the lower left can be either manned or unmanned, and depicts the evolution of current long-range jet-propelled aircraft into the Mach 3 speed range. Such vehicles will probably fly in the 60,000-to 100,000-ft. altitude region. Because of the low density of the atmosphere in this range, heat transfer rates will be less than 2 B.t.u./(sq.ft.) (sec.). Heat transfer rates of over 50 B.t.u. (sq. ft.) (sec.) would occur if the cruise vehicle were to fly at Mach 3 at sea level; the importance of reduced air density in heat transfer is illustrated by this comparison.

The importance of exposure time is also emphasized by the cruise vehicle. Even though heat transfer rates are low, the time of flight is sufficiently long that, assuming no cooling or use of insulation, the temperature of the airframe will eventually become rather uniform at a value approximating the stagnation temperature of 600° F. Thus, from the materials and structural standpoint, the problem of thermal stress will exist during a portion of the flight time owing to temperature gradients, and finally adequate strength and stiffness will have to be achieved at a temperature level substantially higher than airframe designers have contended with up to the present.

In the lower right corner is a typical short-range, high-speed air defense missile. This missile is representative of a variety of missile types which may be described as ordnance or aeroballistic missiles since they have generally replaced bombs, artillery, and guns for air-weapons applications. Such missiles might be used in the lower atmosphere and reach velocities of the order of Mach 5. Peak heat transfer rates as high as 10 B.t.u./(sq. ft.) (sec.) could be reached. Rapidly changing velocities

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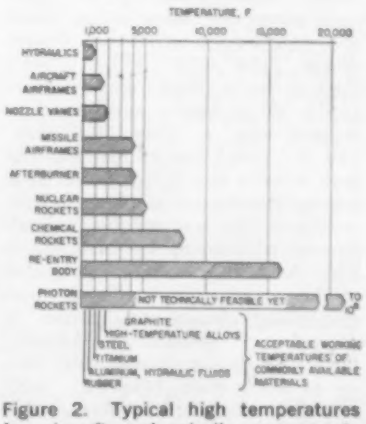

Figure 2. Typical high temperatures for aircraft and missile components

High temperatures

continued

and the short intervals of flight of the order of 5 min. or less result in a highly transient heating situation. As a consequence, the total amount of heat transferred to the missile would be small, and except for stagnation regions, temperatures are such as to permit use of materials like aluminum and magnesium.

The compensating effect of radiation heat transfer in hypervelocity vehicle design is embodied in the concept of the hypersonic boost-glider shown in the upper left corner. This type of vehicle is launched by boost rockets to some altitude above the order of 150,000 ft., and then it glides to its destination while decelerating gradually in the thin upper atmospheric air. The range, operating altitudes, and flight velocity of boost-glide vehicles are all closely related; a vehicle of intercontinental range would have a flight time of about 60 min. and a maximum heating rate of less than 10 B.t.u./(sq. ft.) (sec.). For this duration of exposure and heating rate it can be shown that the rate of heat loss by radiation from the airframe surface will equal the aerodynamic heating input if the surface temperatures of the airframe approach 2,500° F. Structural designs capable of retaining their integrity at equilibrium conditions approaching 2,500° F. will require substantial advances in materials technology. A more likely approach will involve cooling and insulation techniques whereby the interior of the vehicle can be maintained at levels suitable for human occupancy; there seems little doubt that from other considerations, including the forces resulting from acceleration and deceleration, manned hypersonic gliders are feasible.

Last, but not least, is the ballistic missile reentry body in the upper right corner. For blunt bodies having low weight-drag ratios, thus slowing down significantly while passing through the less dense, upper portions of the atmosphere, a maximum heat transfer rate of about 500 B.t.u./(sq. ft.) (sec.) may be realized. This heat transfer rate is predicated upon the maintenance of a laminar boundary layer, and assumes that no mass transfer phenomena are occurring to alter the heat transfer characteristics of the boundary layer. Should more streamlined slender-body shapes be utilized, and should the boundary layer be turbulent, heat transfer rates up to 5,000 B.t.u./ (sq. ft.) (sec.) may be obtained. It is obvious that the heating rates for missile reentry

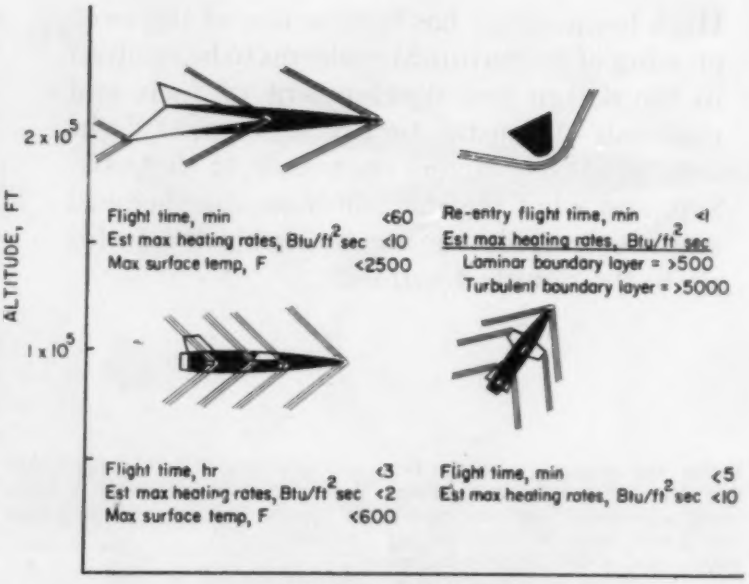

Figure 3. Aerodynamic heating of typical flight vehicles

bodies are several orders of magnitude greater than for other types of high-speed vehicles, and that it would be desirable to maintain laminar boundary layers.

The design variable not yet mentioned in connection with reentry is the extremely short duration of exposure which is less than 1 min. Thus, even though heat transfer rates are high, the total amounts of heat involved are not impossible to cope with. The heat sink technique, whereby materials capable of both absorbing large amounts of heat and of conducting heat away from the surface fast enough to prevent melting or undue reduction in strength, is one possible answer. The opposite approach could be termed a thermal resistance technique wherein the design objective is to utilize materials with low thermal diffusivities so that surface temperatures will reach high values while the subsurface material maintains its structural integrity. A variety of mass transfer techniques such as melting, vaporization, sublimation, surface combustion, and injection systems can be included within the broad scope of thermal resistance design.

Figure 4 illustrates the role of chemistry in the problem of aerodynamic heating. The altitude for which the curves are plotted is 161,000 ft. The specific numerical values given would be different for other altitudes. Nevertheless, the general nature of real gas effects is clearly depicted. Up to about Mach 6 or 7, air deviates only slightly from perfect gas behavior when passing through shock waves and coming to rest in stagnation regions on flight vehicles. For speeds beyond the Mach 6 or 7 range, however, dissociation begins and the ratios of diatomic molecules of O_2 and N_2 usually found in air are altered by the presence of these gases in their atomic state. The lower part of Figure 4 shows the mole fractions of the various constituents in the gas at stagnation conditions for Mach numbers up to 28. At the highest Mach numbers the first stage of ionization can also be seen.

One characteristic of the departure of the stagnation temperature of a real gas from that of a perfect gas, as shown in the upper part of Figure 4, is important to the flight vehicle designer. Although real gas stagnation temperatures are lower than for a perfect gas, the total enthalpy of the gas for either case is approximately the same; the energy in the perfect gas system is represented by the dissociation and ionization processes instead of by the random molecular motion defining temperature in the perfect gas system.

Another characteristic, from the surface materials standpoint, is the effect of the surface of a vehicle on the recombination process for a dissociated gas during the cooling of a boundary layer as heat is transferred to the vehicle. A noncatalytic surface could inhibit the recombination process and thus reduce the amount of heat available for transfer to the surface. On the other hand, a catalytic surface

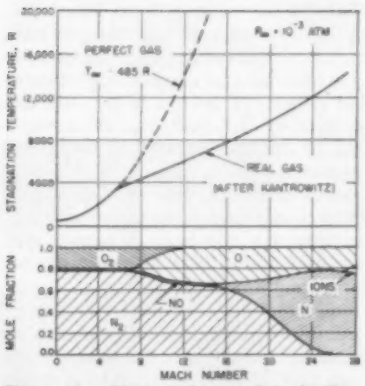

Figure 4. Dissociation and ionization of air

could facilitate surface recombination and make available a substantial portion of the total heat in the gases for transfer to the surface. Thus chemical reaction kinetics are important from the standpoint of real gas effects, and from the standpoint of surface chemistry effects. Furthermore, the chemical aspects of corrosion and oxidation can be different from air for real gas conditions of exposure.

Conventional propulsion systems

The environmental conditions confronting the designer of conventional chemical-reaction jet propulsion power plants have been long established. Generally, temperatures of the working fluids in conventional units are higher than in the materials used for construction of the device since the heat is developed by chemical reaction within the fluid itself. However, equilibrium temperature conditions are usually established rapidly (even in rockets) and cooling techniques are commonly required.

Table 1 lists four types of chemical-reaction propulsion systems with the temperature ranges that may be encountered; the operating times, and some of the basic chemical conditions that must be allowed for in combustors, nozzles, and in the case of gas turbines, the afterburner. It can be seen that temperature levels in propulsion units are the highest that materials engineers must contend with, exclusive of the missile reentry problem.

The status of high-temperature alloys for service as nozzles and turbine blades in air-breathing gas turbines under sustained, high stress conditions has been briefly mentioned earlier in this article. Years of development effort have provided nickel and cobalt base alloys of good strength and creep characteristics for many

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Table I. Characteristics of chemical reaction propulsion systems

Type	Temperature range of exhaust gases, °F	Operating durations	Chemistry and materials considerations
Air-breathing ramjets and turbojets using hydrocarbons and high-energy fuels	1600 to >4000	Up to several hundred hours	Exhaust gases are usually oxidizing owing to use of excess air to reduce material temperatures. Dissociation of about 1% depending on temperatures and pressures.
Solid propellant rockets	2500 to 5000	0.05 to >100 sec.	Exhaust gases are usually reducing. About 5% dissociation limited by relatively high pressures and medium temperatures. Various salts, nitrogen oxides, and sulfur oxides may be in gases. Salts may act as flux on refractory nozzle materials. No cooling usually available for nozzles.
Liquid propellant rockets using standard and high energy fuels	4000 to 8500	1 to >300 sec.	Exhaust gases may be highly reactive, and on an over-all basis are usually reducing. Level of dissociation may reach over 10%. Hence, oxidizing conditions can occur at local spots owing to presence of dissociated oxides.
Free-radical fueled rockets and air-breathing engines	3000 to 5000	1 to >300 sec.	Present concepts are in early exploratory stage. Problems are most likely to be in low-temperature storage and handling. High-temperature problems probably less severe than other types of chemical-reaction propulsion systems.

Table 2. Characteristics of new types of propulsion systems

Type	Operating temperatures, °F	Remarks
HEAT TRANSFER		
Nuclear	>2000 for air breathers 3000-5000 for rockets	Nuclear fission is source of heat for heating air in gas turbines or ramjets, and light gases such as H_2 and NH_3 in rockets. Reactor materials at higher temperatures than working fluids. Strong radiation fields present.
Plasma	Up to 20,000°F	Light gases are ionized in high-intensity electric arcs, then ejected through nozzles in conventional rocket manner. Active molecular fragments can react with containing structure.
Solar	8000°F	Collectors gather radiant energy from sun which is then transferred to a working fluid for discharge through a rocket nozzle.
Ion acceleration (For space flight only)		
Ions accelerated by electrostatic fields		Materials needed to supply large quantities of ions. Structural materials will be subject to sputtering by ion bombardment.
Photon (For space flight only)		
High-intensity light directed as a jet	Up to 10^9	Principle based on conversion of mass to energy according to Einstein relation $E = mc^2$. Not technically feasible because materials not available with sufficient reflectivity to collimate light without melting.

High temperatures

continued

hours of use in an oxidizing atmosphere at temperatures around 1,600° F. Interest in refractory metals like molybdenum is prompted by their potential usefulness at temperatures of over 2,000° F; at the same time interest is deterred by the susceptibility of such materials to oxidation. The oxidizing atmosphere in gas turbines results from the use of air as a diluent to cool the products of combustion down to acceptable levels, plus the fact that CO_2 and H_2O can be reduced by certain classes of materials. Gas turbine afterburners and ramjets present another environmental condition to the materials engineer in that fuel-air ratios approaching stoichiometric are used, with the consequence that temperatures in the jet stream can approach flame temperatures of the order of 3,500 to 4,000° F. Depending upon the amount of preheat imparted to the incoming air by ram compression, these temperatures could even reach the order of 6,000° F. Hence, cooling of tailpipes of afterburners and ramjets is generally required.

Temperatures and heat fluxes in rocket engines are an order of magnitude greater than air-breathing jet engines. For example, heat fluxes in excess of 3,000 B.t.u./(sq. ft.)(sec.) are possible in the throats of rocket engine nozzles. The duration of exposure is quite low, ranging from a fraction of a second to a few minutes at most. Solid propellant rockets have no means of cooling the nozzles, so resort to temperature resistant ceramics is the course usually followed in nozzle design. Since the exhaust products of solid propellants are reducing, ceramics of the carbide and nitride types can be used satisfactorily. Liquid propellant rockets usually depend upon regenerative cooling of the nozzle and combustor to maintain materials temperatures at reasonable values. This technique is satisfactory for the hydrocarbon-oxidizer propellants in common use today where combustion temperatures of up to 5,700° F. are attained. For the so-called "exotic propellants" of the future, where combustion temperatures can reach as high as 8,500° F., there is some question about the effectiveness of regenerative cooling, and other techniques such as film or transpiration cooling may be needed. The exotic propellant, such as hydrogen and fluorine, also present many handling problems to the materials engineer other than those shown in Table 1 for the exhaust gases.

Brief mention of free-radical fuels and their applications is noted in Table 1. Interest exists in such fuels because of the possibility of obtaining the highest specific impulse now conceived for any chemical-reaction system of energy release. From an application standpoint, the recombination of hydrogen radicals provides the advantage of a low molecular weight exhaust gas plus a heat release rate substantially greater than with molecular reactions. The real problem in free radical fuels is to produce and store the radicals, which to date have been done only at extreme low temperatures in the laboratory.

New propulsion systems

A variety of new types of propulsion systems has been under consideration and investigation for several years. With the exception of nuclear systems, the new propulsion methods are essentially in their conceptual stages. As a result, the detailed environmental conditions that must be understood by designers are largely undefined. Increased emphasis on hypersonic speeds and space flight can be expected to stimulate research on these new systems in the next few years with the consequence that the materials engineer can soon look forward to having the necessary data for the materials aspects of the systems.

Table 2 lists some details of new propulsion systems that are of interest: (1) an indication of the probable maximum temperatures that may be encountered and, (2) some general remarks on the environmental characteristics as related to materials. Three general categories are indicated in Table 2; namely, heat transfer, ion acceleration, and photon. The latter two categories are of interest for interorbital space flight only since they have low thrust-weight ratios and are incapable of accelerating themselves against any strong gravitational field. Ion propulsion systems appear to be technically feasible, and exploratory studies of the engineering aspects of this type of propulsion system are in progress. Photon propulsion systems are theoretically possible, but are not technically feasible until ways of dealing with controlled ultra-high-temperature nuclear reactions are devised.

Heat transfer propulsion systems represent an immature art at present, but at least in the case of nuclear systems, one that is bound to become a reality. Heat transfer propulsion systems differ from chemical reaction systems in that materials temperatures in part of the system are higher than those of the working fluids, hence the great concern and attention to materials. Air-breathing nuclear-powered gas turbines and ramjets may operate for periods of several hours, and are subject to the oxidation characteristics of air. Nuclear rockets using low molecular weight gases such as hydrogen or ammonia will have short running times comparable to conventional rockets, but the heat exchanger will be functioning in a reducing atmosphere. The complications of strong radiation fields always serve to complicate nuclear-powered propulsion systems of any type. Nuclear rockets can have high thrust-weight ratios and are thus suitable for boost application as well as for space flight. The plasma jet and solar energy rockets probably are destined for space flight application only.

Structural Design

The variable force has not been specifically discussed since, in the final analysis, the objective of airframe and engine designers is to achieve a light, efficient load-bearing structure. All of the usual design problems continue to exist, although they are complicated by the high-temperature considerations outlined.

Because of the short flight times and tremendous accelerations that occur with certain types of rocket-propelled vehicles, there is one special area of loading environment that is receiving increased attention from materials engineers today. This is the short-term stress-strain characteristic of a material obtained both at constant temperatures and at transient temperature conditions. Information is needed on the response characteristics of materials to extreme loadings lasting of the order of only seconds. With such data, plus the usual types obtained in the past, the materials engineer should be capable of aiding design engineers cope with the broad spectrum of environmental conditions now foreseen.

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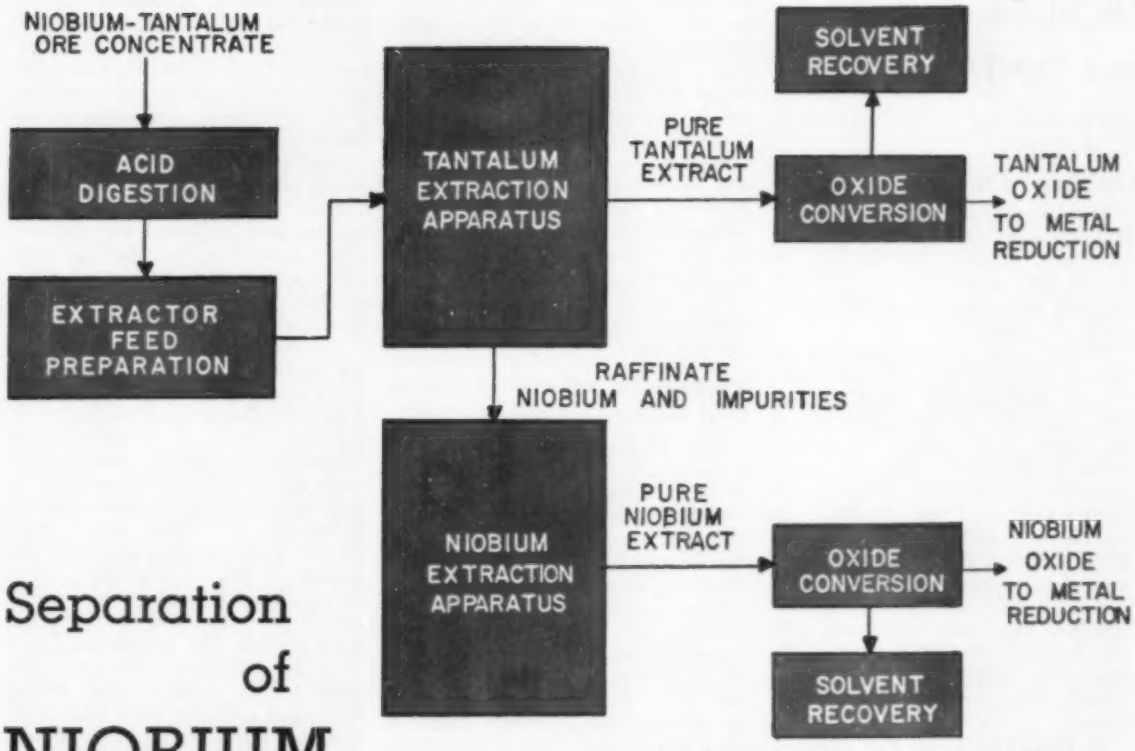

Figure 1. Proposed process for the separation of niobium and tantalum

Separation of NIOBIUM and TANTALUM by liquid extraction

A simple process is demonstrated for the preparation of high-purity niobium and tantalum oxides from a columbite ore. For those anticipating the processing of columbite ore on a large scale this process seems worthy of study.

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INCREASED INTEREST has been shown in the metal niobium during recent years. Because niobium has a high melting point (4376°F) and a low-neutron cross section, the Atomic Energy Commission has encouraged research on new methods of winning the metal from its ores with the ultimate hope of finding a process which would yield niobium metal at a reasonable price. The two areas of endeavor in which the principal difficulties in finding such an economic process occur, are the separation of tantalum from the niobium and the conversion of purified niobium salts to the metal. The purpose of this research was, then, an attempt to eliminate the troublesome area of the separation of tantalum and niobium.

There have been many papers published concerning the history and literature review of tantalum-niobium separations (*1*, *2*, *3*, *4*, and *5*).

The process selected is shown schematically in Figure 1. It was necessary to develop methods for carrying out the individual steps in the process and to determine operating conditions and chemical and equipment requirements.

The investigation was divided into five sections: (1) opening of the ore, (2) preparation of the extractor feed solution, (3) separation of niobium and tantalum, (4) solvent treatment

and recovery, and (5) final conversion of products.

Opening of the ore

The source material for the earth oxides was a columbite ore concentrate from Nigeria. The analysis of the ore used in this investigation was made by the Ledoux Company and is shown in Table 1.

The 65-mesh ore concentrate, as received, was ground to pass 325 mesh.

Acid dissolution of columbite ore. The columbite ore concentrate could be dissolved in sulfuric or hydrofluoric acids, but in order to obtain economical separation of niobium and tantalum the final feed solution must be niobium and tantalum fluoride. Each acid was tested in some detail and the resulting procedures compared. It was desirable to eliminate filtration steps since experience with the fusion process showed that filtrations of various niobium and tantalum salts were extremely troublesome.

Wilhelm (*6*) found that niobium-tantalum ores could be successfully opened by hydrofluoric acid, that 90% reaction of the ore was possible when a 100% excess of cold 70% hydrofluoric acid was shaken with ore concentrate for 8 to 12 hr.

Excess hydrofluoric acid was known to decrease separation factors in the extraction process and hence was undesirable. Hydrofluoric acid requirements for the Nigerian columbite ore were calculated as approximately 92 g. of 70% hydrofluoric acid/100 g. of ore. Since about 5% of the ore was unaccounted for by the Ledoux analysis, it was arbitrarily decided to increase the requirements to a one-to-one weight ratio.

A series of laboratory digestion runs was made from which it is believed safe to assume that a reaction time of 4 hrs. in a suitable vessel, designed to eliminate hydrofluoric acid losses, would give nearly a complete reaction of the ore. Volume requirements for the reaction vessel were determined to be 0.192 gal./lb. of ore processed.

Preparation of the extractor feed solution

The source materials used for niobium and tantalum contained about 20% total iron and manganese and roughly 5% tin and titanium. In order that final purity of the niobium and tantalum be high, it was necessary to eliminate these foreign materials as early as possible in the extraction procedure. Early experiments utilizing aqueous feed solutions showed iron to be present in tantalum to the extent of 0.25 to 0.50%. The elimination of titanium was especially desirable since it associated itself with niobium and its removal necessitated a separation which is achieved with great difficulty.

Countercurrent leaching with hexone. Direct filtration of the hydrofluoric acid-columbite ore reaction mass resulted in incomplete recovery of the niobium and tantalum fluorides. Complete recovery was effected when the filter cake was washed with water but this procedure also dissolved the iron, manganese, titanium, and tin fluorides which contaminated and diluted the original solution. Washing the aqueous fluoride cake with hydrofluoric acid was moderately successful but this scheme proved uneconomical as the hydrofluoric acid requirements became excessive.

Leaching the reaction mass with hexone proved to be the most effective method tested. Four countercurrent leaches were employed for each reaction mass. The final leach in each case was either fresh hexone or hexone acidified to one normal with hydrofluoric acid.

The first leach was made by mixing the second leach solution from a previous run directly with the reaction mass. The slurry was then filtered to apparent dryness on a polyethylene Buchner funnel. In all cases the first leach resulted in recovering 70% or more of the niobium-tantalum fraction of the ore. The filtrate volume from the first leach increased 25% over the amount of hexone originally added. No significant increases were noted in any of the volumes of the following three leaches. The second leach was made by transferring the filter cake back to the reactor and mixing thoroughly with the third leach solution from a previous run. This solution usually contained about 16% of the niobium and tantalum. Repeating the above procedure for the third leach resulted in a solution containing 6 to 7% of the niobium and tantalum.

When the fourth leach was made with fresh hexone, little niobium and tantalum were found in the filtrate. However, if the fresh hexone were first acidified to one normal with hydrofluoric acid, 2 to 3% more of the niobium and tantalum was recovered.

Filtration difficulties ceased when the hexone leach procedure was used. Attempts to filter the aqueous reaction mass failed as the cake set up on the filter before complete recovery of the liquid could be effected. Filtering the reaction mass hot eliminated some of this difficulty, but the problem of recovery still remained.

When the first organic leach solution was filtered, the solids always came out of the reactor intact. This first filter cake resembled a piece of gelatin until all the liquid was removed. Subsequent filter cakes were then very granular in nature and filtered with great ease. The color of the filter cakes progressed from a dark brown after the first filtration to a light tan after the final filtration.

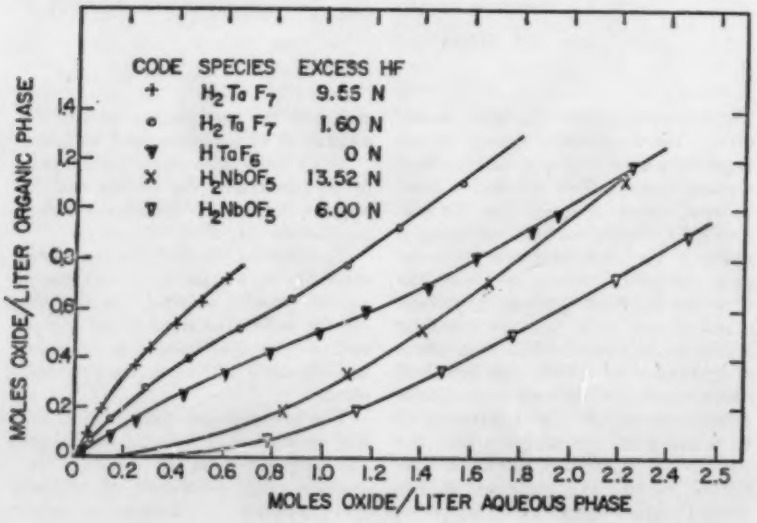
CODE SPECIES EXCESS HF
+ H_2TaF_7 9.55 N
o H_2TaF_7 1.60 N
▼ $HTaF_6$ 0 N
X H_2NbOF_5 13.52 N
▽ H_2NbOF_5 6.00 N
MOLES OXIDE/LITER ORGANIC PHASE
MOLES OXIDE/LITER AQUEOUS PHASE
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.5
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4

Figure 2. Distribution curves for pure niobium and tantalum fluorides with hexone.

Detailed filtration studies were not conducted on the above filter cakes. The characteristics of the cakes were such that high filtration rates were always effected, and hence a detailed study was deemed unnecessary. Each filter cake was filtered four times, once after each washing. By calculation, a filter area of 0.791 sq. ft./lb. of ore processed on a cake thickness of 1 in. was determined necessary.

The washing or leaching of the filter cake was determined to be an important part of the process. Countercurrent washing, as carried out on the bench scale, repeatedly yielded recovery of 95 to 96% of the niobium and tantalum in the ore. To yield the same results on a larger scale, it was determined that a filter such as the Bird Prayon or Eimco Pan would be necessary. These filters have the reputation of high cake-washing efficiency and sharp separation of filtrates, two features which fit in well with the proposed procedure. Because of the corrosiveness of hydrofluoric acid and the toxicity and inflammability of hexone, such a filter would be completely enclosed. The whole unit could be constructed of Monel, but a cheaper method would be to employ plastics and plastic coatings. Before any material of construction is chosen, it is recommended that corrosion tests be made.

The wet cake contained 0.18 to 0.20 lb. of hexone/lb. of solids. For economical operation this hexone should be recovered. Drying of the fluoride cake was not investigated.

Separation of niobium and tantalum

Conditions for the separation of niobium and tantalum were determined by simulated column runs. Both diethyl ketone and hexone were used in these runs. Nine simulated column runs were made under varying conditions. In all cases the niobium and tantalum were present with excess hydrofluoric acid in the organic phase. Various concentrations of sulfuric acid were tested as the aqueous scrub solution. The tantalum preferentially remained in the solvent while the niobium and minor impurities were scrubbed into the aqueous raffinate.

Single-stage extractions with hexone. Single-stage liquid-liquid extractions were used to obtain distribution coefficients of pure tantalum and pure niobium in hydrofluoric acid solutions with hexone. Extractions were made by shaking equal volumes of feed solution and virgin hexone in a polyethylene container. All shakeups were made for 2 min. even though no further changes in distribution were noted after 30 sec. The phases were then separated for analysis.

Distribution data for three tantalum stock solutions and two niobium stock solutions are shown in Figure 2. The concentrations in Figure 2 are shown in moles per liter to allow for more direct comparison.

An accurate determination of the excess hydrofluoric acid concentration was desired for the primary stock solutions. The procedure used for the excess hydrofluoric acid concentration was the determination of the fluoride ion by a modified Willard and Winter (7) analysis. This method was found satisfactory on standard solutions of tantalum and niobium in hydrofluoric acid.

Figure 2 shows that an increase in excess hydrofluoric acid concentration increased both the tantalum and niobium distribution coefficients. It is also apparent that the niobium distribution is more affected by an increase in acid concentration than is the tantalum. Foos (5) has presented a possible explanation for the lack of preferential extraction of tantalum at higher hydrofluoric acid concentrations by the following reactions.

$$7\ HF + H_2TaO_4 = H_2TaF_7 + 4H_2O \quad (1)$$

$$5\ HF + H_2NbO_4 = H_2NbOF_5 + 3H_2O \quad (2)$$

$$2\ HF + H_2NbOF_5 = H_2NbF_7 + H_2O \quad (3)$$

The products of reactions 1 and 3 are very similar while the niobium and tantalum salts from reactions 1 and 2 are quite different. It would be expected that the relative extractability of fluotantalates and the fluoniobiates might be similar while for the fluotantalates and the oxyfluoniobiates it might be different. Thus, if an amount of hydrofluoric acid insufficient to yield appreciable amounts of reaction 3 were present, considerable difference in niobium and tantalum extractability should result.

Werning and associates (4) also reported data on the extractability of tantalum and niobium at various hydrofluoric acid concentrations. This work showed that tantalum extractability apparently reached a maximum at about 6*N* hydrofluoric acid while the extractability of niobium continued to increase at hydrofluoric acid concentrations as high as 15*N*.

Figure 2 also revealed that an increase in concentration also increased the distribution coefficient of both tantalum and niobium. However, it is interesting to note that the niobium distribution coefficient apparently increased until the aqueous solution was approximately one molar and then remained constant. This same effect is also noted for the tantalum distribution coefficient until the aqueous solution was approximately 0.5*M*.

The fluoride ion determination revealed that the species $HTaF_6$ was present with no excess hydrofluoric acid. The proximity of the curve (middle curve, Figure 2) to the other tantalum curves showed that $HTaF_6$ was not as extractable as H_2TaF_7. It has been suggested many times that tantalum and niobium fluorides are extracted by ketones through hydrogen bonding. If this be the case then, it follows that the $HTaF_6$ species is not as extractable as H_2TaF_7 because of the deficiency of hydrogen.

Simulated column runs using Diethyl Ketone and Hexone. A diethyl ketone solution containing 209 g. of oxide/liter and assaying 41.8% tantalum oxide and 58.2% niobium oxide was used in the following tests. A fluoride determination also showed this solution to be 3*N* in excess hydrofluoric acid.

Since the distribution coefficient of niobium increased more than the distribution coefficient of tantalum at increased concentrations, it would be expected that the separation factors would increase with decreased niobium-tantalum concentrations. To check this conclusion, a series of one-stage extractions were made with the above diethyl ketone solution. One molar sulfuric acid was employed as the aqueous phase in this test. The results of these one-stage shake-outs are shown in Figure 3.

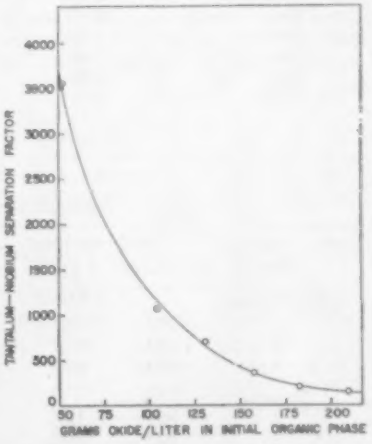

Figure 3. Effect of initial feed concentration in diethyl ketone on tantalum-niobium separation factors.

NIOBIUM and TANTALUM

Figure 3 shows that the tantalum-niobium separation factor increased rapidly when the initial feed concentration was decreased below 100 g. of oxide/liter. However, even at concentrations above 200 g. of oxide/liter, a separation factor of over 130 was present. All the organic phases analyzed 90% or more tantalum oxide. Similarly all the aqueous phases contained 90% or more niobium oxide. In view of the high separation factors obtained, this phenomenon was to be expected.

A method for predicting the separation of niobium and tantalum by liquid extraction was desired. Since the organic phase was tantalum-rich and the aqueous phase was niobium-rich after only one contact, it was thought that the pure component curves from Figure 2 could be used for this prediction. However, no completely successful method was found.

Since the systems sulfuric acid-tantalum and niobium fluorides-diethyl ketone or hexone were too complicated for calculation of stage requirements for equilibrium data by standard methods, extraction stages were determined empirically by a series of simulated column extractions. These simulated column runs were used to provide the same data as a countercurrent extraction by the use of polyethylene separatory funnels as extraction stages. The flow pattern was arranged to simulate countercurrent flow of solvent and sulfuric acid.

A fractional extraction technique was used in which the feed was introduced at an intermediate point in the extractor. The organic solvent and an aqueous scrub solution were fed to opposite ends of the extractor.

In the analysis of the extraction operation the mixer-settler was divided into extraction and scrub sections. The region between the solvent entry point and the feed stage was taken as the extraction section. The action of the solvent was to reduce the amount of tantalum leaving with the raffinate solution. In the feed stage, essentially all the niobium along with some tantalum was transferred to the scrub solution entering the extraction section. The function of the extraction section was to prevent any of the tantalum from leaving the extraction unit in the raffinate. The entering solvent progressively extracted the tantalum and niobium from the aqueous phase and carried back to the feed stage all the tantalum leaving the feed stage. Since the solvent preferentially extracted tantalum, the aqueous phase grew progressively richer in niobium although both materials were being transferred to the solvent. Thus, a tantalum-free niobium concentrate left the extractor in the aqueous phase, or raffinate.

The scrub section was defined as the region from the scrub entry to the feed stage. The solvent entering the scrub section came from two sources, the feed and the organic solution from the extraction section. The action of the scrub solution was to progressively decrease the relative concentration of niobium in the solvent since the scrub solution preferentially extracted niobium. Thus, as the solvent passed through the scrub

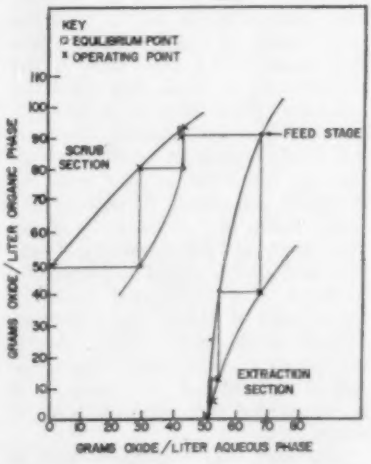

Figure 4. Equilibrium diagram for the fifth diethyl ketone simulated column run.

Table 1. Ledoux Analysis of Nigerian Columbite Ore

Constituent	Percent
Nb_2O_5	61.93
Ta_2O_5	6.80
FeO	18.65
MnO	1.51
TiO_2	3.48
SnO_2	2.86
H_2O	0.01
	95.24

Table 3. Stagewise Analysis for the Fifth Niobium-Tantalum Simulated Column Run Using Diethyl Ketone

Stage No.	Organic phase: Vol. (ml.)	Organic phase: G. oxide/liter	Organic phase: % Ta_2O_5	Aqueous phase: Vol. (ml.)	Aqueous phase: G. oxide/liter	Aqueous phase: % Nb_2O_5
1	43.5	49.48	>99.99	52.0	29.36	0.013
2	43.3	80.43	>99.99	51.5	43.14	0.020
3	46.0	93.00	>99.99	55.0	42.01	3.33
4	46.0	90.83	99.44	55.5	68.29	87.00
5	27.0	40.62	90.38	56.0	54.93	96.55
6	24.0	12.22	39.97	54.0	52.40	99.74
7	26.2	5.21	4.09	54.0	51.54	>99.93

Table 2. Summary of the Conditions for the Simulated Column Runs

Run	Feed solution: G. oxide/liter	Feed solution: % Ta_2O_5	Feed solution: % Nb_2O_5	Flow rate, ml./cycle: Feed	Flow rate, ml./cycle: Solvent	Flow rate, ml./cycle: Scrub	No. of stages	Feed stage	% Ta_2O_5 in extract	% Nb_2O_5 in raffinate
Diethyl Ketone										
1	209	41.8	58.2	30	30	120	6	5	99.95	>99.93
2	209	41.8	58.2	35	35	140	9	7	99.98	99.60
3	209	41.8	58.2	50	50	160	7	4	>99.99	>99.93
Hexone										
2	209	16.1	83.9	50	50	100	7	4	>99.99	>99.93
3	292	16.1	83.9	50	50	100	7	4	>99.99	99.93
4*	305	14.0	86.0	50	50	100	9	5	>99.99	98.85

*Not steady-state conditions. Purpose of run was to obtain an estimate of various stagewise densities for interface control on continuous mixer-settler.

. . . various extraction process details were determined in many simulated extraction column runs shown by tables.

section, both niobium and tantalum were transferred to the scrub solution, but the preferential action of the scrub removed relatively more niobium, leaving niobium-free tantalum in the exit solvent phase.

Several simulated column runs were made with both diethyl ketone and hexone feed solutions (data summarized in Table 2).

For the diethyl ketone feed solution, the conditions employed in the fifth simulated column run were found to yield pure tantalum in the organic and pure niobium in the aqueous raffinate.

The extraction process under these conditions was carried out for 100 cycles, although only the products from every tenth cycle were analyzed. Analyses of the liquid phases in each stage were carried out after the extraction process was completed.

The cycle analyses indicated that about 40 cycles of operation were required to closely approach steady state. These analyses showed that the niobium delivered in the aqueous product contained less than 700 p.p.m. tantalum. These data were substantiated by the stagewise data which appear in Table 3. It was noted from these data that the tantalum in the equilibrium organic phase of stages 1, 2, and 3 was spectrographically free of niobium. Since high-purity tantalum was obtained in these three end stages, it is probable that the contamination of the tantalum by niobium in the organic product phase was considerably less than 100 p.p.m., the lower limit of detection.

Analyses of the aqueous product phase indicated that the niobium in this phase contained less than 700 p.p.m. tantalum. Although this was the limit of detection for tantalum in niobium, it was estimated (8) that the niobium probably contained less than 300 p.p.m. tantalum.

The equilibrium stagewise data were plotted in Figure 4. Compatible operating line data were found in the extraction section. The curvature of this line was explained by the volume changes noted in the data. The operating line for the first three stages of the scrub section defined a nearly straight line. However, the large amount of mass transfer, occurring near the feed stage, undoubtedly caused volume changes which caused the operating line to curve a little. The position of the operating point between stages three and four could not be explained. The odd curvature of the equilibrium curve in the scrub section was probably the contributing factor for this effect.

The equilibruim stagewise data (Figure 4) also revealed that the equilibrium aqueous concentration in stage three was less than the aqueous concentrations of stages two and four. It was apparent that something was being added in the feed which affected the scrub stage adjacent to the feed stage since this same effect was noted in all the simulated column runs with diethyl ketone.

The excess hydrofluoric acid was determined in each organic and aqueous equilibrium phase. Results are shown in Table 4. The total amount of fluoride was determined in each equilibrium phase. From the analyses the amount of fluoride required for H_2TaF_7 and H_2NbOF_5 was calculated. The excess hydrofluoric acid concentration was determined by difference. Some negative excess hydrofluoric acid values were found in the scrub section of the extractor. This probably meant that some $HTaF_6$ was present in these streams. This effect, however, was determined to be helpful to the separation.

It was seen earlier in Figure 2 that $HTaF_6$ was not as extractable as H_2TaF_7. Hence, if some $HTaF_6$ were present in the extractor, it would prefer the aqueous phase and thus increase the recycle of solutes.

The excess hydrofluoric acid concentration increased rapidly between the equilibrium aqueous phases of stages three and four. It was probable then that the acid concentration affected the oxide concentration in these stages.

Hexone solutions containing various concentrations of niobium and tantalum oxides and excess hydrofluoric acid were next employed. The first simulated column run with hexone

continued on next page

Table 4. Stagewise Excess Hydrofluoric Acid Determination for the Equilibrium Phases of the Fifth Simulated Column Run Using Diethyl Ketone

	Organic phase		Aqueous phase	
Stage no.	Total HF (moles/l.)	Excess HF (moles/l.)	Total HF (moles/l.)	Excess HF (moles/l.)
1	1.403	−0.165	0.892	−0.038
2	2.131	−0.417	1.468	0.101
3	2.656	−0.292	1.773	0.433
4	3.275	0.394	4.461	1.945
5	2.090	0.912	4.197	2.142
6	1.362	0.941	3.851	1.881
7	1.016	0.821	3.170	1.231

Table 5. Stagewise Analyses for the Second Niobium-Tantalum Simulated Column Run Using Hexone

	Organic phase			Aqueous phase		
Stage No.	Vol. (ml.)	G. oxide/liter	% Ta_2O_5	Vol. (ml.)	G. oxide/liter	% Nb_2O_5
1	43.8	16.88	>99.99	51.0	20.39	0.050
2	46.0	39.14	>99.99	52.0	33.92	0.044
3	45.5	53.69	>99.99	53.3	36.83	7.43
4	45.0	57.44	97.57	58.0	85.43	84.37
5	25.5	28.64	82.65	56.0	81.59	97.67
6	25.0	11.50	48.65	53.0	80.79	99.45
7	26.0	6.09	5.00	54.0	76.92	>99.93

Table 6. Stagewise Analyses for Niobium-Tantalum Continuous Extraction Run

	Organic phase		Aqueous phase	
Stage no.	G. oxide/liter	% Ta_2O_5	G. oxide/liter	% Nb_2O_5
1	25.35	>99.99	14.15	0.12
2	39.65	>99.99	14.18	3.20
3	40.73	99.97	11.27	44.69
4	34.34	96.70	35.17	86.30
5	60.12	47.03	125.9	96.70
6	53.33	19.79	130.8	99.02
7	49.80	7.35	132.1	99.61
8	48.20	1.80	132.7	99.86
9	39.80	0.82	125.9	>99.93

was a short test to check mass transfer and settling rates. The same flow rates that were used in the fifth diethyl ketone run were used in this and following tests. The aqueous scrub solution was 0.1 *N* sulfuric acid equilibrated with hexone. The organic extraction solution was virgin hexone. The feed solution for this run was a hexone solution containing 292 g. of oxide/liter and assaying 16.1% tantalum oxide and 83.9% niobium oxide. The excess hydrofluoric acid concentration was determined to be 4.4 *N*. From this short test it appeared that hexone was identical to diethyl ketone as an extraction solvent as the mass transfer, settling rates, and end-product purities were very similar.

In the second simulated column run with hexone, an attempt was made to study the effect of composition on the separation. A portion of the above feed solution was diluted with hexone to yield a feed solution containing 209 g. of oxide/liter and 3.15 *N* in excess hydrofluoric acid concentration. The flow conditions are presented in Table 2. Thirty cycles of this run were made, the run was stopped, and the equilibrium stages analyzed. The results are presented in Table 5 and Figure 5.

Since the feed concentration, excess hydrofluoric acid concentration, and extraction conditions were similar for the second hexone run and the fifth diethyl ketone run, comparison of the data from these runs indicated the effect of feed composition on the extraction. This comparison was true if the diethyl ketone and hexone were assumed to have equal extraction power for this system. A comparison of the equilibrium stagewise composition showed diethyl ketone a slightly better extracting agent than hexone. However, since product purities were apparently identical, it was difficult to attach a significant difference between the extracting power of these two ketones in this particular system.

The effect of composition on the extraction was clearly seen by comparing Figures 4 and 5. Increasing the niobium content of the feed solution caused both equilibruim curves to shift. Since identical flow rates were used in both runs, the extraction equilibrium curve shifted to the right because of the increased niobium content in the aqueous phases. Similarly the equilibrium curve for the scrub section shifted to the left because of the decreased tantalum content in the scrub equilibrium aqueous phases. Both equilibruim curves were shifted downward because of the decreased tantalum content in the equilibrium organic phases.

A third simulated column run using hexone was made to study the effect of higher feed concentrations on the extraction. The conditions of the run are shown in Table 2. Eighty-one products were taken off this run with the products from every tenth cycle analyzed. Analyses of the liquid phases in each stage were carried out after the extraction process was completed.

The cycle analyses indicated that less than 20 cycles of operation were required to closely approach steady state. These analyses showed that the tantalum delivered in the organic extract contained less than 100 p.p.m. niobium. The nobium raffinate was assayed and showed less than 700 p.p.m. tantalum present. These data were confirmed by the stagewise data which were plotted in Figure 6. As expected the higher concentration in the feed solution shifted the equilibrium curves. It was also noted that the reversal effects present in the diethyl ketone runs of the scrub stage adjacent to the feed stage were absent. Apparently the excess hydrofluoric acid distribution between equilibrium phases was not as drastic as had been found in the diethyl ketone runs.

The effect of feeding virgin hexone into the extractor was evident in Figure 6. Employing sulfuric acid equilibrated hexone in place of virgin hexone would probably remedy this situation and decrease the curvature of the operating line.

It was desired to test the separation process as predicted by the preceding simulated column runs in a pilot plant extractor. The Nigerian ore concentrate reported in Table 1 was the source material for the niobium and tantalum.

Approximately 15 gal. of hexone feed solution were prepared using the recommended procedure. The solution contained 305 g. of oxide/liter assaying 14.0% tantalum oxide and 86.0% niobium oxide. The excess hydrofluoric acid concentration was determined as 5.4 *N*.

A 16-stage polyethylene, mixer settler extractor, developed at this laboratory, was available. In order to properly set the interface controls on the extractor, stagewise density data were necessary. A fourth hexone simulated column run was made to obtain the stagewise density data. The conditions of this run are presented in Table 2.

The aqueous product from stage nine assayed 1.15% tantalum oxide in niobium oxide, indicating that

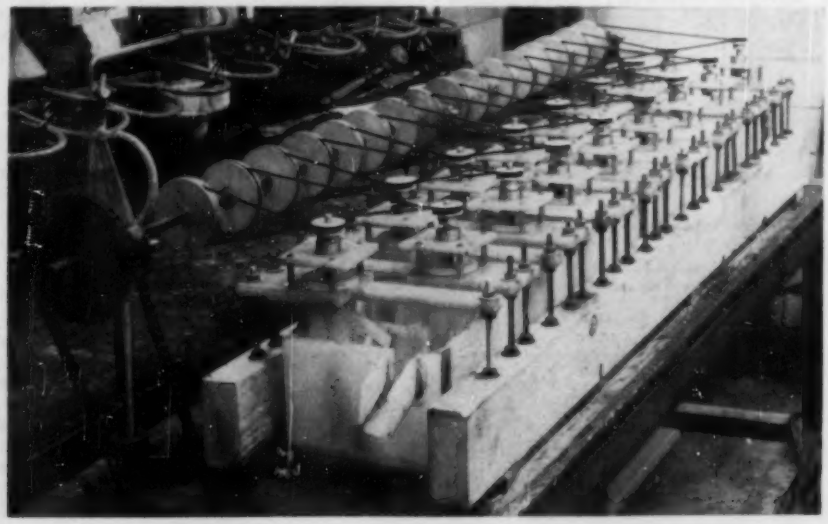

Figure 7. Photograph of extractor.

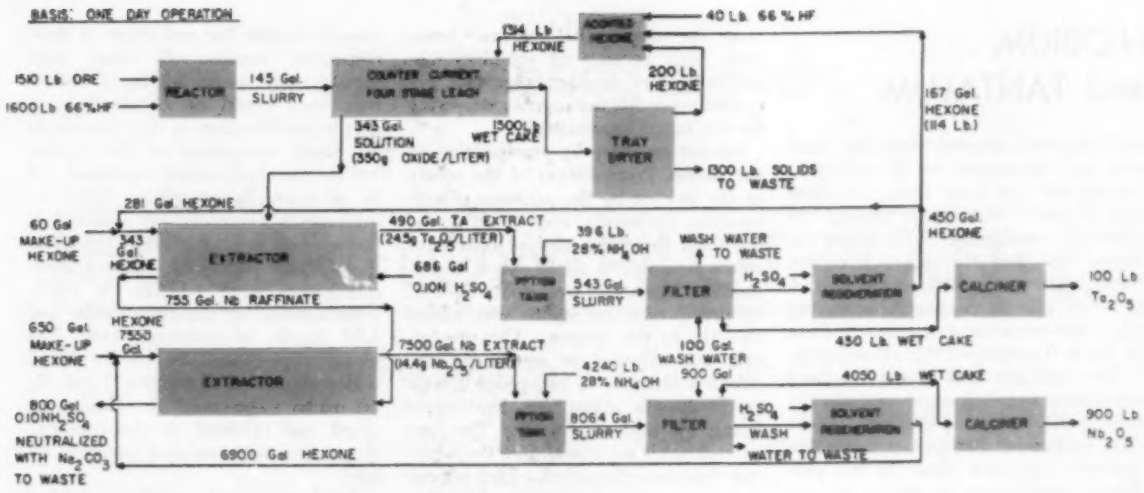

Figure 8. Quantitative flow diagram for the proposed process

steady state had not been reached. The main purpose of the simulated column run was to obtain the density relations of the equilibrium phases. For the purpose intended, these data were suitable. However, it was also desired to obtain good equilibrium data so that a comparison between the predicted equilibrium and the actual equilibrium in the continuous extractor could be made. It was probable that the steady-state equilibrium conditions did not warrant a rerun of the simulated column.

Continuous countercurrent extraction run. A 16-stage polyethylene, mixer-settler-type extractor (9) was employed for the continuous extraction run. Since this extractor was still under development, this run also served to test the operational characteristics of the extractor. Only ten stages of the extractor were actually used, nine stages for the extraction and the tenth stage as a raffinate overflow. Figure 7 is a photo of extractor.

The continuous extraction run was carried out for 11 hr. The hexone feed solution was added at stage five at a rate of 44 ml./min. Aqueous scrub was added at stage one and virgin hexone was added at stage nine at a rate of 88 and 44 ml./min., respectively. No difficulty was encountered with the interface control or settling of phases during the run. Attempts to run at higher flow rates caused settling difficulties in stages eight and nine. However, this difficulty was attributed to the extractor and not the system as the capacity of the extractor was probably being exceeded.

Before the liquid holdup in the extractor was displaced once, i.e., before one throughput, tantalum containing less than 100 p.p.m. niobium was being produced in the extract product. After approximately two throughputs, the raffinate product contained niobium with less than 700 p.p.m. tantalum. The difference in the time element before the pure products were noted was probably due to some contamination of the extraction solution while the flow rates were being adjusted. Higher flow rates than those finally settled upon were first attempted. An emulsion formed in stages eight and nine causing some organic solution from the scrub section to back up into the extraction section, which undoubtedly caused higher tantalum concentrations than ordinarily present.

At the end of the extraction run the equilibrium phases were removed from the extractor and assayed. The data obtained are presented in Table 6. It was apparent from these data that the actual equilibrium concentrations did not correspond to the predicted values. Periodic checks of the flow rates were made during the course of the run. For the first 10 hr. the flow rates were essentially the same as those set at the start. However, the last check, made just before the run

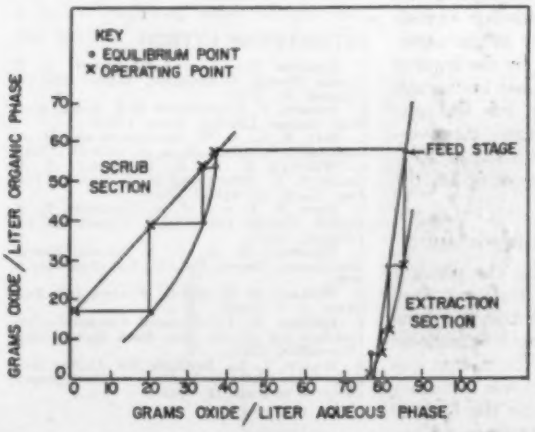

Figure 5. Equilibrium diagram for the second hexone simulated column run

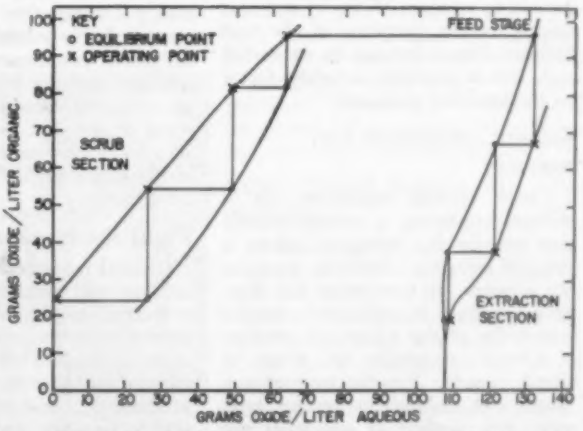

Figure 6. Equilibrium diagram for the third hexone simulated column run

was stopped, showed that the feed rate had decreased to 25 ml./min. During the last hour then, this flow rate changed drastically enough to affect the equilibrium of the extractor. Since the time necessary for one throughput was a little more than 1 hr., the change was still occurring when the extractor was stopped. Data in Table 6 confirmed this observation.

The raffinate and extract product containers were changed periodically during the course of the run. These data confirmed that the extractor apparently operated close to the predicted equilibrium as shown by the raffinate and extract concentrations. For the first 10 hr. of the run the extract and raffinate streams averaged 22 and 108g. of oxide/liter, respectively, comparing with 20.2 and 111.3g. oxide/liter from the simulated column run.

The sulfuric acid raffinate from the first extractor contained the niobium and the minor impurities present. In order to produce reactor-grade niobium oxide, it was desired to separate the niobium and the minor impurities by a second extraction. Tests employing the simulated column technique showed that both a large volumetric flow rate of organic to aqueous and a large number of stages were necessary.

However, when a continuous extraction was made employing 15 stages, a volumetric flow ratio of organic to aqueous of four to one was found to extract about 95% of the niobium in the original feed. Since it was impossible to increase this flow ratio without exceeding the capacity of the extractor, a volumetric flow ratio of organic to aqueous of ten to one was chosen for the purposes of the cost analysis. This value may be somewhat high but it provided a safety factor for the final cost estimate.

Solvent treatment and recovery

Under normal conditions for a process employing a solvent separation process the extracted solute is stripped from the solvent by an aqueous solution. In most cases this stripping operation is sufficient to remove essentially all the solute and produce a solvent acceptable for reuse by direct recycle. For the case of tantalum and niobium in hexone, however, this method of operation was not acceptable. Such large volumes of aqueous solution were necessary to strip the solute that hexone losses were high because of solubility. In addition, the number of stages required exceeded the number necessary for the initial separation.

Solvent recovery by precipitation of the solute. Precipitation of the solute in the hexone by the addition of ammonium hydroxide was found to be the most desirable method tested for solute removal. A slight excess of ammonium hydroxide over that required to precipitate the solute was added directly to the hexone. The precipitate was allowed to settle and the solution filtered. A two-phase filtrate resulted with about 7% by volume being an aqueous phase. The two phases were separated and the aqueous solution discarded. The hexone was regenerated by equilibrating with a small volume of dilute sulfuric acid. Ninety-two per cent of the hexone was recovered in this manner. Acid requirements were determined as 0.012 lb. sulfuric acid/lb. of hexone regenerated.

The scale at which these extractions were made did not allow for extensive tests on solvent recycling or degradation. Single-stage shake-up tests were made to compare the extracting power of virgin and regenerated hexone. The regenerated hexone was the better extraction agent in every case. In addition, volume changes were less severe. It was concluded that equilibrated hexone should be used for all the extractions and that regenerated hexone was suitable for reuse provided it was regenerated under the above conditions.

Solvent losses. The losses of solvent in the extraction process were quite small and therefore difficult to measure. Hexone losses by evaporation were undoubtedly present. However, if a closed extractor were employed, evaporation losses would be negligible. The principal sources of loss for hexone were probably solubility in the aqueous phase, entrainment by the leaving raffinate, and the 8% loss in the solute stripping operation. For the purposes of the cost estimate, the overall solvent loss was estimated at 10% of the initial amount required for the extraction.

Final conversion of products

General requirements. The purified niobium and tantalum fractions were converted to the hydroxides in the solvent recovery scheme. Separation of the hydroxides from the solvent was effected by filtration. It was necessary to wash, dry, and calcine the hydroxides to tantalum and niobium oxides. For the purposes of this proposed process the purified oxides were assumed suitable for reduction to their respective metals. If other salts proved more useful for metal reduction, they could be obtained by a simple modification in the process or by direct conversion of the oxides.

The wet hydroxides contained 3.5 lb. of water/lb. of solids. Filter requirements, computed for a plate and frame pressure filter, were 0.33 sq. ft./lb. of oxide produced. Ammonia requirements were 1.11 lb. of 100% ammonia/lb. of tantalum oxide and 1.32 lb./lb. of niobium oxide. The yields were essentially 100%. Wash water amounted to roughly 1 gal./lb. of oxide. The washed cakes were dried and calcined at about 800°C. to produce niobium and tantalum oxides.

Product purities. The niobium and tantalum oxides produced by this method were spectrographically pure with respect to each other. Trace impurities were determined by emission spectrograph. The tantalum oxide was spectrographically full of foreign elements. The niobium oxide contained about 750 p.p.m. iron, 500 p.p.m. silicon, and 120 p.p.m. titanium.

Discussion

The preparation of high-purity niobium and tantalum oxides from a columbite ore by a simple inexpensive process was demonstrated. Although further testing on a pilot plant scale would be needed before designing a large-scale plant, the process studied seems worthy of consideration for those anticipating the processing of columbite ore on a large scale.

ACKNOWLEDGMENT

The authors wish to express their appreciation to the Ames Laboratory of the Atomic Energy Commission for the support of this project.

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Presented at A.I.Ch.E. meeting, Chicago, Ill.

Engineering aspects of a HOUDRIFLOW PILOT PLANT

Pilot plants designed to simulate Houdry catalytic units produce same percentage conversion as their commercial counterparts. Design considerations and operating results are given.

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Sun Oil Company, Marcus Hook, Pennsylvania

EARLY IN 1954 the need was recognized for a completely integrated pilot plant to simulate TCC, Houdriflow, and Houdresid processes. It was required that the plant operate with a minimum catalyst inventory and reasonable oil throughput, and produce data consistent with commercial operations. Preliminary studies revealed that two units of different physical size would be required to cover the desired ranges of operating variables. Consequently, a small unit was designed to study limited size catalyst samples, with a larger unit designed for as wide a range of operating flexibility as practicable.

General description of units

Figure 1 shows the general arrangement of equipment for each unit. In normal operation the unit is filled with a bed of pellet or bead catalyst from the catalyst meter to a point in the catalyst hopper. When the flow of catalyst is started, it moves by gravity from the hopper down through the reactor and kiln to the meter which regulates the rate of catalyst movement. From the meter the catalyst falls freely into the engager. There it is picked up by a stream of hot air and lifted to the disengager from which it flows by gravity into the hopper to complete the cycle.

The charge oil is fed by a gear type metering pump through a preheater and vaporizer to the reactor. Process steam is added as the charge enters the preheater. Product vapors leaving the reactor are cooled to condense the synthetic crude. The uncondensed gases are metered, sampled, and discarded.

Steam is used as a sealing medium above and below the reactor to prevent the escape of hot oil vapors. Part of the steam entering the top seal zone also serves to hydrate the catalyst descending into the reactor.

The physical sizes of the units were developed from considerations of (1) reactor design criteria, (2) kiln design, and (3) seal leg requirements. As a result of discussions with representatives of Houdry Process Corporation, it was decided that reactor beds should have a minimum diameter of two inches and a minimum depth of thirty inches. The completed units have two-inch diameter beds with depths of thirty-six and ninety inches, respectively. The kilns were designed by Catalytic Construction Company to cover ranges of coke burning rates commensurate with the rates of coke laydown expected, due consideration being given to types of charge stocks, ranges of charging rates, and kinds of processes being simulated. The required lengths of seals were based upon the expected pressure differentials and established values of allowable adverse pressure gradients. The over-all heights of the completed units are about thirty-seven and sixty-eight feet, respectively.

Support and expansion problems

As shown in Figure 1, the main supports for the units are located near the top of the kiln and at the corresponding elevation on the air lift pipe. In operation, the entire unit is heated to a temperature of about 1,000°F. Since it is constructed of austenitic type stainless steel throughout, the larger unit grows about five inches in height above the support point in heating up to operating

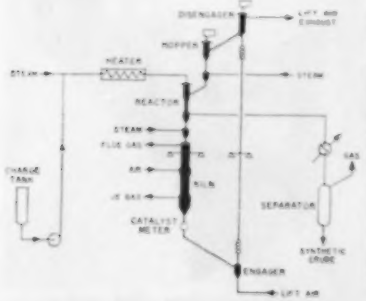

Figure 1. Houdriflow pilot unit—schematic layout

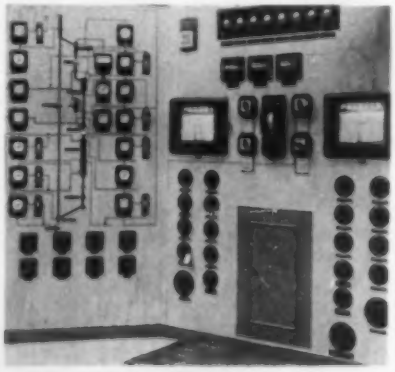

Figure 2. Houdriflow pilot unit—control panel

Houdriflow pilot plant
continued

temperature. Two constant load hangers at the top of the unit allow for this expansion while carrying a large part of the weight. Differential expansion between the reactor-kiln side of the unit and the air lift side is taken up by two bellows-type expansion joints in the air lift pipe. They are sized for a maximum temperature difference of about 200°F.

The use of stainless steel throughout was based on several considerations. These were: (1) physical strength at the operating temperatures, (2) corrosion and oxidation resistance, and (3) prevention of contamination which could affect control equipment, product purity, product distribution, or catalyst activity. Type 316 stainless steel was used in the construction of the reactors and other oil processing equipment. The kilns were made of Type 347. Charge and receiver tanks were fabricated of carbon steel.

Instrumentation and control

The use of extensive instrumentation and automatic control was indicated on these units for the following reasons:

(1) The values of all significant variables must be determined at many points throughout the units.

(2) All variables must be maintained as nearly constant as possible.

(3) Because of the comparatively small size of the units, it would be virtually impossible to hold constant pressure differentials manually.

(4) Manpower requirements would be very high without automatic controls.

Practical operation required that all instrumentation be grouped at one point. Figure 2 is a photograph of the control panels for the smaller unit. The modified graphic panel on the left contains all of the instruments for the control of pressures, pressure differentials, and related variables. The right-hand panel contains the temperature indicators, recorders, and controllers and the Variac transformers for the many electric heaters on the unit.

The graphic panel instruments are Swartwout "Autronics." (Manning, Maxwell & Moore "American Electronic" instruments are used on the larger unit.) From the beginning of design work, it was suspected that the system would respond very rapidly to pressure changes. Consequently, electronic transmission and control were chosen to eliminate time lags in the instrumentation. Even though the instrument panels are located immediately adjacent to the units, many of the transmission lines are over fifty feet in length with closed loops exceeding one hundred feet. The wisdom of this choice was borne out in practice because many of the pressure control loops cycle in three seconds or less.

Pressure control

Figure 3 is a schematic diagram of some of the pressure control instruments which were seen on the graphic panel (Figure 2). In contrast with commercial unit design, it may be noted that the exhaust from the air lift disengager is not directly open to the atmosphere but is controlled by a back-pressure valve. By this means, the air lift is operated at the same general pressure level as the rest of the unit. Thus, operations at pressures up to about 50 lb./sq. in. gauge are practicable without using excessively long seal legs. To operate at such a pressure with the disengager at one atmosphere would require a top seal leg about 200 feet long. On this unit, the seal legs were made only long enough to allow for the pressure differentials resulting from the flow of vapors or gases through the various operating zones. The top seal leg on the smaller unit is three feet long, and the reactor and kiln seals are each one foot long.

With seals as short as one foot, differential pressures across the seals are quite low, thus requiring very sensitive control instruments. Consider the problem of maintaining a seal between reactor and kiln. The reactor bottom seal also functions as a purge zone for stripping oil vapors from the spent catalyst. This operation requires about six to ten pounds of steam per hour. The resulting pressure drop through this seal is about three to five inches of water column. Since the kiln top seal is also one foot long, the same pressure drop across it requires an equal steam flow. (Equal flows through these seals are desirable to simplify the problem of measuring the flow through each.) Now, for these pressure differentials to be equal, the pressures at the bottom of the reactor and at the top of the kiln must also be equal within a few inches of water.

For example, if it is desired to maintain a differential of four ± one inches across these seals, the absolute pressures in the reactor and in the kiln must be controlled to ± one inch of water. At a system pressure of 50 lb./sq. in. gauge, it would be impossible to attain such precision with conventional pressure controllers referenced to atmosphere. To obtain the required sensitivity, a differential pressure controller with a range of zero to twenty inches of water is used to control the pressure in each vessel with both controllers referred to a common static pressure. By setting both controllers to the same differential, the pressures in the two vessels may be maintained equal and constant within the sensitivity limits of the controllers, namely, about ± one-fourth inch of water. The pressure level at which the unit is to be operated may be readily set by adjusting the reference pressure. In Figure 3 it may be seen that PC-1 controls the pressure at the bottom of the reactor, PC-2 controls that at the top of the kiln, and PC-3, that at the disengager. The reference pressure is set by PC-6, which is a sensitive reducing-relief valve of a type employed for set-point loading of pneumatic control instruments. With this system the pressures at the top of the kiln and at the disengager are kept constant within ± one-half inch of water. The pressure at the reactor outlet fluctuates about ± one inch of water.

Various additional instruments are used to measure and control differential pressures across seal legs and the lift pipe, although some of these have been omitted from this drawing (Figure 3) for clarity. PC-4 controls the steam flow through the reactor bottom seal and is usually set at four inches of water. PC-5 controls the reactor head seal at about one inch of water. This differential is kept as low as possible to minimize dilution of the incoming oil vapors with the seal steam. The transmitter signal of this control loop is amplified by a factor of five to produce a full range signal at the recorder and controller of only four inches of water. Flow recorders are provided on the seal steam lines. Air to the lift is controlled

Figure 4. Houdriflow pilot unit—adiabatic controller chassis

by a flow indicating controller. This instrument is equipped with a low-flow alarm to give warning of faulty operation. The top seal leg, the kiln top seal, and the lift pipe are each provided with differential pressure indicators and *High-Low* alarms. Temperature controllers, which operate valves in the flue gas lines, regulate the supply of air to the kiln burning zones.

Adiabatic control

Special controllers developed by the Applied Physics Section of the Sun Oil Manufacturing Department, Engineering Division, are used to maintain adiabatic conditions in the reactors. Figure 4 is a photograph of the electronic chassis of one of these controllers. They consist essentially of d-c chopper type inverter-amplifiers which control the current in the adiabatic heater windings by means of series-connected saturable core reactors. (The reactor is not shown in the photograph.) The amplifier receives an unbalance signal from a differential thermocouple, the hot junction of which is located in thermal contact with the heater, with the "cold" junction located on the vessel wall or within the catalyst bed. When temperatures are equal at the hot and "cold" junctions, the "error" signal is zero, and the heater current is being maintained at its proper value. Since the controller has no means of determining automatically this "proper value" at any given temperature level, a manual "reset" is provided for finally equalizing the two temperatures. In no case, however, will the two temperatures differ by more than the "proportional band" of the controller, i.e., the temperature change which will drive the heater current from minimum to maximum. The width of this band may be varied by a second manual control, which is, in effect, a sensitivity adjustment. A meter on the front panel shows the current to the control winding of the saturable core reactor. The units are equipped with a *Manual-Off-Automatic* switch and a manual control knob whereby the heater current may be adjusted to any desired value independently of the thermocouple. This feature is useful for keeping the unit hot during stand-by periods.

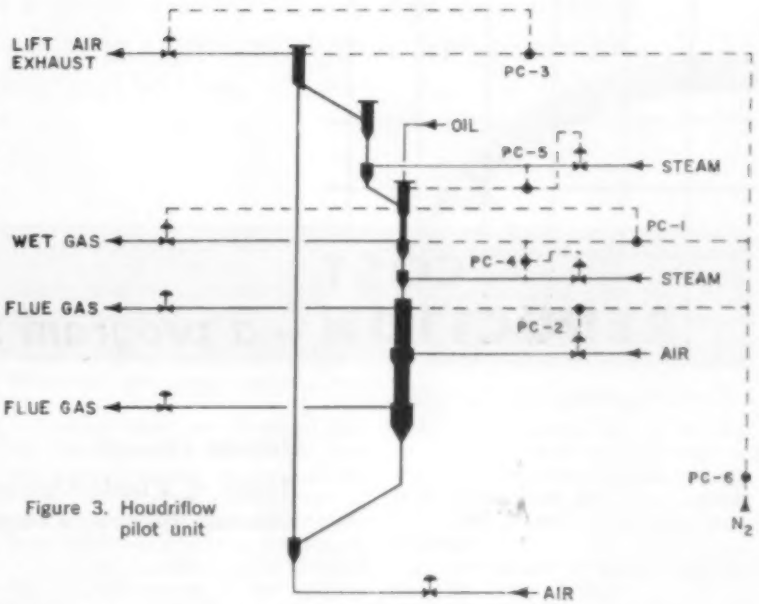

Figure 3. Houdriflow pilot unit

Comparison with commercial plant

Both pilot units have been operated with a variety of catalysts and charge stocks over a comparatively wide range of operating conditions. For results of the pilot plant operation to be useful, data obtained should agree closely with those from commercial plants. Figure 5 graphically compares product distributions from a commercial Houdriflow plant with those from the larger pilot unit. Excellent agreement is demonstrated. Both units were running the same charge stock over the same catalyst. Previously developed correlation charts were used to convert the actual pilot plant data to the reactor conditions of temperature, catalyst-to-oil ratio, recycle ratio, and oil partial pressure prevailing in the commercial plant. Conversions and product distributions are expressed on the fresh feed basis. The ratio of recycle stock to fresh feed in the charge was 0.05.

At equivalent operating severities, conversion in the pilot unit is greater than that in the commercial plant. Thus, at equal space rates, namely 1.03, the conversion levels were 50.6 and 54.3 vol. % in commercial and pilot plants, respectively. A conversion of 50.6% required a space rate of 1.03 in the commercial plant vs. 1.28 in the pilot plant. This result can be attributed to a more uniform distribution of oil vapor in the pilot plant reactor. The distance from oil inlet point to reactor wall is only 1 in. in the pilot unit but about 10 ft. in the commercial plant. The improved flow distribution in the pilot reactor effectively decreases the space rate and increases the catalyst-to-oil ratio.

Presented at A.I.Ch.E. Chicago Annual Meeting, December, 1957.

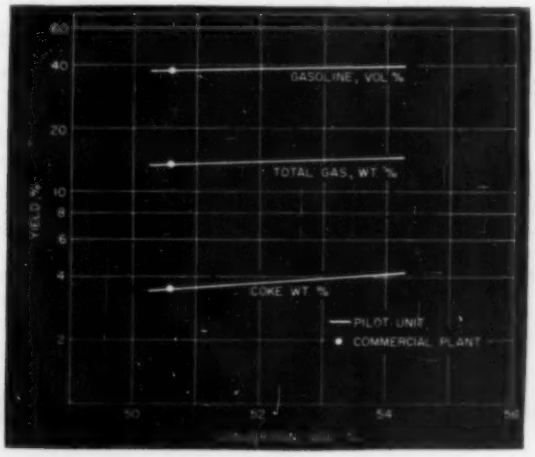

Figure 5. Houdriflow pilot unit — performance curves

COST REDUCTION — a program that works

REUBEN GUTOFF
Resins & Fluids Operations
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THE STORY APPEARS on the financial pages every day—rising sales and declining earnings. This need not be the case if proper emphasis is given to cost reductions as an integral functioning part of operations. Such a program has been in operation at the Silicone Products Department of the General Electric Company for the past six years, during which annual savings of about 8% of manufacturing costs have been realized.

A review of the following five elements, necessary for the successful operation of such a plan will help bring the over-all program into focus.

1. Establishment of cost reduction budgets
2. Determining cost reduction policies.
3. Organization of a cost reduction team
4. Stimulation for maximum individual participation
5. Measurement of performance.

Cost reduction budgets

Budgets should not be plucked from the air, but must be definitely related to the profit requirements of the business. Frequently this is not done and cost reduction goals are nothing more than a arbitrarily chosen percentage of shop costs or fixed number of dollars per year. To be at all meaningful, a profit-oriented budget should be determined to counterbalance the profit threatening influences of rising costs of raw materials, labor, supplies, and services. (see Table 1)

In some industries where this has been an historical fact, reduced selling prices of finished products is another influence to be factored into the cost reduction program. The dollar impact of each of these influences must be calculated and studied from the over-all business viewpoint. For example, labor costs should be analyzed not only for direct labor but for indirect labor, clerks, secretaries, salesmen and administrative personnel—in other words, the entire payroll. The influence of merit raises, normal progression increases, and cost of living bonuses must be calculated.

Other factors to be considered in setting cost reduction budgets include increases in costs of supplies and services other than raw materials and labor. These factors are often incorrectly neglected. In many chemical businesses the importance of anticipated plant product mix charges can not be omitted in setting cost reduction budgets. This factor often exerts tremendous leverage on operating costs.

At the least, the annual budget must be set to counteract increased costs if the business is to maintain previous profit levels. A decision to do otherwise may be tantamount to a decision to go out of business.

Cost reduction policy

The goals of the effort should be clearly defined by management and a formal organization outlined to do the job. In our department, the Standard Practice Instruction covering cost re-

Reuben Gutoff is associated with the Silicone Products Department.

Table 1—Profit oriented cost reduction budget

1958 PROFIT REDUCTION FACTOR AS COMPARED WITH 1957	%	TOTAL/ DOLLARS (M)	NET/ DOLLARS (M)
Increased labor costs	5	5,000	250
Increased raw material costs	7	10,000	700
Increased cost of other supplies and services	3	2,000	60
Reduced selling prices	2	20,000	400
			$1,410

To be meaningful a profit-oriented budget should counterbalance the profit-threatening influences of rising costs of raw materials, labor, supplies, and services.

duction is prefaced by this statement:

"It is the policy of the Silicone Products Department that effort will be continually applied to increase productivity, maximizing material utilization and improving procedures thereby improving profitability at the same time as the Department's responsibilities for product quality, customer service, and safety of employees are not only preserved but improved."

This policy also establishes a basis for consistent evaluation of the efforts which lead to cost reductions in the department. The cost reduction team is the group which carries out these efforts, focuses attention on the need for reductions, encourages and appraises cost reduction activities.

Organization

The cost reduction team in the Silicone Products Department is composed of personnel throughout the entire organization—from manufacturing engineering, product engineering, and finance. This team is guided by an advisory council headed by the plant superintendent. Its secretary and most important member is the plant industrial engineer. The organization also includes about eight separate idea teams, which include representatives of such functions as various production operations, maintenance, pilot plant, quality control, purchasing, marketing, engineering, and finance.

These groups meet regularly, each month, and discuss ideas which appear to offer cost reduction potentials in all parts of the business. Ideas on which immediate action can be taken or at least considered are forwarded to the appropriate units in the organization; for more complex suggestions, formal study projects are organized.

The idea teams operate most effectively when they concentrate on specific problems during their meetings. For example, the financial idea team spent one of its recent sessions discussing the possibility of using leased cars instead of private vehicles for salesmen travel. An outgrowth of this particular session was a $15,000 annual cost reduction put into effect a few months later.

Once the ideas are generated, they must be followed up and evaluated. Even in the simplest cases, this normally involves a program to establish what savings are potentially available, and whether this project will adversely affect other phases of operations. In some cases, the projects themselves take many months to complete.

These projects are integrated into the regular work of the people who are concerned with the evaluations. Often this requires readjustment of schedules and priorities to enable the most important jobs to be performed.

For example, after a recent break-in and introduction of a new silicone resin into the plant, the process engineer came up with an idea for increasing yields of this resin by recovering useful resin from filter cake as a final part of processing. This idea seemed desirable enough to have the process engineer continue his work on it rather than taking up other planned projects. A cost reduction of better than $10,000 was the result.

Completed cost reduction figures are checked by the advisory council for validity and accuracy. Often the council will ask the originator of the idea to provide additional details. The formal acceptance or rejection by the council is based on criteria established in the Standard Practice Instruction.

In addition to processing completed projects, the advisory council also meets at least once annually with each idea team; issues a monthly report summarizing progress against budget; and, stimulates and promotes the overall department cost reduction effort.

Stimulating participation

To arouse interest and to develop an awareness that cost reduction is everyone's job, the following three-point program has been promulgated.

1. Careful selection of idea team members
2. Assignments of specific roles to each idea team member
3. Tangible recognition of outstanding individual performances

Members of the idea teams are chosen to achieve the best possible balance of wide participation and common interests. For example, a production area team might include two foremen, two process engineers, a product chemist, and a cost accountant. Each member of the team is conscious of responsibility for contributions to cost reduction activities in its designated area even though the area foreman has immediate, day-by-day responsibility there. This awareness encourages the cross-fertilization of ideas necessary to a successful creative program.

The foreman concentrates on daily

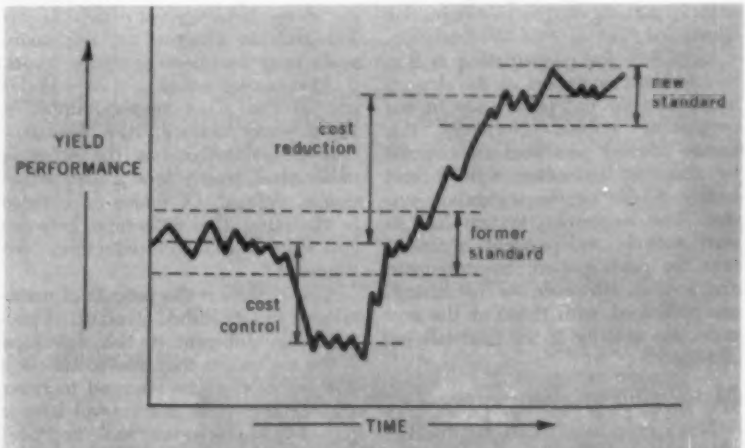
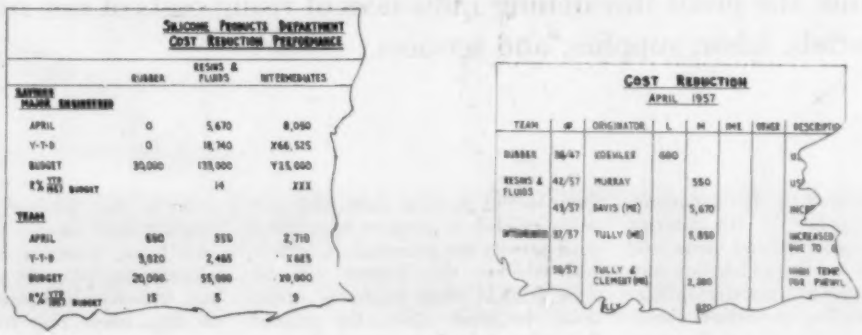


Figure 1. Cost reduction vs. cost control



ME—major engineer,
L—labor,
M—materials,
IME—overhead
Y-T-D—Year to date

Figure 2. Fragment of monthly report of advisory council comparing cost reduction performance with budget.

Cost reduction

continued

efforts to obtain better control of materials and supplies and boost labor productivity. The process engineer works on improving process efficiency or "horizontal cost reductions." The product chemist tries to design products which can be made at lower costs without sacrificing quality, the so-called "vertical cost reductions." The cost accountant who studies the area operation seeks to determine the greatest potentials for savings.

Each idea team is supported by a group of contributors who feed it ideas and support its work on projects. This introduces an additional element of interest and makes it possible to have every professional member of the manufacturing organization actively participating in cost reduction efforts.

Eligibility for participating is limited to those members of the department who do not participate in our suggestion system. Normally this means salaried personnel are covered by the cost reduction activity and hourly people by the suggestion system. The suggestion system has its own entirely independent organization for participation, measurement, and awards. However, its cost savings are combined with those of the cost reduction activity in the final tallying of results.

Measuring performance

No matter how much emphasis is placed upon creating the proper climate for encouraging cost reduction activity, the program can fail if tangible recognition is not given those who make outstanding contributions. Three factors are used in judging individual contributions: interest, efficiency, and value.

Interest is measured by the number of ideas submitted, with volume the sole criterion. *Efficiency* is determined by ratio of ideas submitted to those adopted. This shows how often each man's thinking brings results. *Value* compares the total dollars of cost reduction achieved with the dollars potentially influenced by a given individual. Obviously, a purchasing agent will have a great deal more opportunity to effect cost reductions than a quality control chemist.

Based on these evaluation criteria, the top individual participants are annually selected and honored by the advisory council. Also each top participant has his achievement on his record when his salary evaluation comes up. Relating cost reduction performance to progress on the salary scale puts the message really across.

As measurement of cost reduction is one of the major responsibilities of the advisory council, it is necessary that all participants in the program understand exactly how a cost reduction is defined. Of major importance is clarifying the difference between cost control and cost reduction. (see Figure 1).

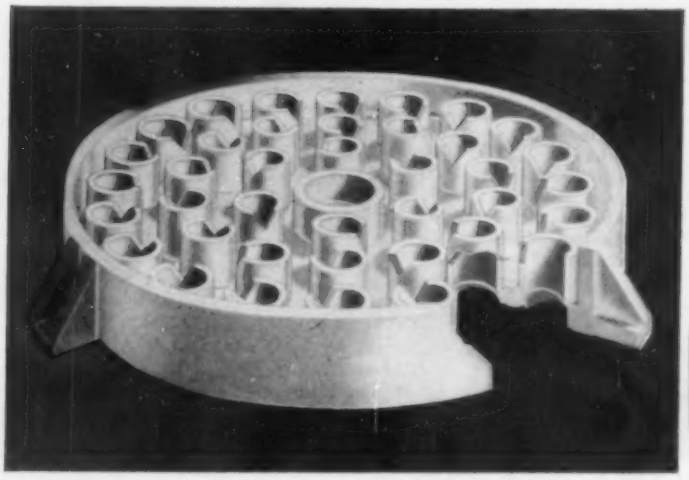
Cost control is the process of maintaining an established standard of performance. Inherent in this definition is the realization that trouble shooting will occasionally be required to bring performance back into control after it has slipped. However, such improvements cannot be considered cost reductions. A cost reduction is defined as the lowering of the accepted standards of cost of either a product or a specific element of cost directly related to a product. A cost reduction must result from a specific planned program and is not allowed if it represents a windfall saving or a general increase in efficiency.

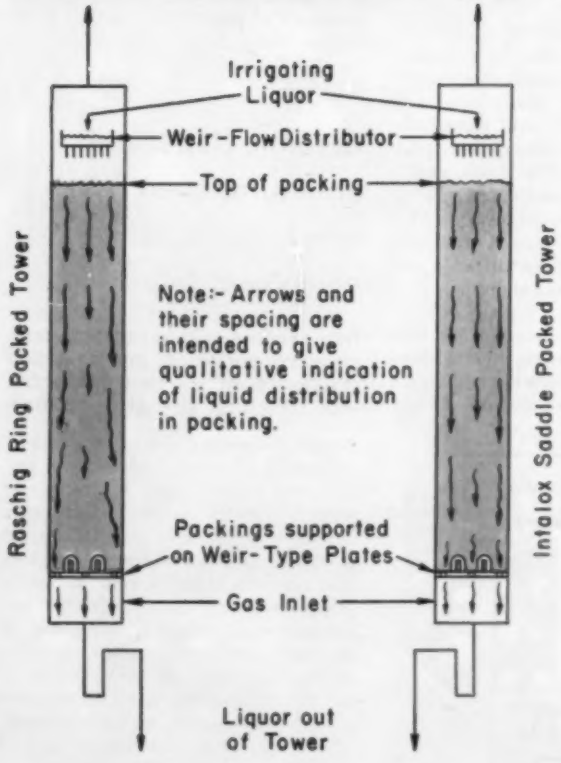
Using these criteria, the advisory council audits claims of cost reductions, issuing a widely distributed monthly report (see Figure 2). This report compares actual cost reduction performance with the budget by each idea team and segregates major engineered from team projects. Major engineered cost reductions evolve from significant engineering programs scheduled by the appropriate managers for completion in a given year. Team cost reductions result from the smaller projects generated and reduced to practice by the Idea Team members. Historically, better than 60% of the cost reductions at the silicone plant have been effected through team efforts. The number of ideas submitted and the backlog submitted but not tested are scanned to pinpoint whether the production of new ideas is slowing down or whether a lag exists in getting action on ideas which have been submitted.

Monthly reports on the claims of cost reduction, issued by the Advisory Council (referred to above), are useful in analyzing monthly profit and loss statement as affected by cost reduction activity. These also permit individual managers to monitor the performance of their own units in this activity. Good performance can be encouraged and ineffectualness checked and improved.

Presented at A.I.Ch.E. meeting, Chicago, Ill.

How to achieve better liquid distribution in PACKED COLUMNS




Irrigating Liquor
Weir-Flow Distributor
Top of packing
Note:- Arrows and their spacing are intended to give qualitative indication of liquid distribution in packing.
Raschig Ring Packed Tower
Intalox Saddle Packed Tower
Packings supported on Weir-Type Plates
Gas Inlet
Liquor out of Tower

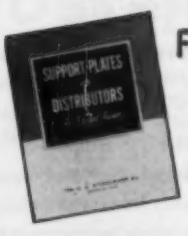
Full utilization of packing surface area in a column can only be realized if liquid distribution (both initially and throughout the bed) is such as to provide maximum *wetted* surface area.

The unique shape of the Intalox Saddle packing permits a thoroughly randomized arrangement of the packed bed, with a virtual absence of pattern packing. Thus, good initial distribution remains intact for greater packed heights than for columns of other packings, notably rings.

Now, U. S. Stoneware makes available two new types of tower distributors, each designed to take full advantage of the better internal distribution of Intalox Saddles. The "Multi-Level" is designed for low liquid rates; the "Weir-Flow"* for medium-to-high liquid rates. Both distributors assure infinitely better initial liquid distribution than the conventional types of distributors heretofore available. While designed for use with Intalox Saddles, they will improve the distribution characteristics of any packed bed.

* *Made in chemical ceramics, carbon steel, or stainless.*

131-F



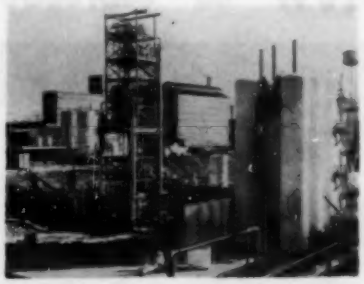
Full details in this NEW Bulletin

Bulletin TA-30 describes these new distributors. Gives data on packing support plates, how to install; when to re-distribute and other data helpful to designers of packed columns. Free on request. Address Dept. CEP 958, U. S. Stoneware, Akron 9, O

U. S. STONEWARE
AKRON 9, OHIO

Table I—Uses of the Methylamines

Monomethylamine	Dimethylamine	Trimethylamine
Surface Active Agents	Fungicides	Choline
Photographic Developers	Herbicides	Drug products
Drugs: Caffeine,	Rubber accelerators	Rocket fuels
Theophyllin, adrenalin	Dimethylformamide &	Trimethylamine-borane
cocaine, tropinone, etc	Dimethylacetamide	& other organo-metallics
Acetate & Vat Dyes	solvents for synthetic	Herbicides
Herbicides	fibers.	Organic intermediates
Tetryl explosives	Dimethyl hydrazine	Reaction media
Insecticides	Dimethyl-boranes and	Lube oil solvent refining
Quaternary ammonium	other organo-metallic	Corrosion inhibitor
compounds	cmpds.	Catalyst
Germicides	Rocket fuels	
	Ion-exchange resins	
	Drugs: Anti-histamine,	
	etc.	



Distillation-storage area of Commercial Solvents plant, Terre Haute, Ind.

New methylamines plant uses high pressure

Terre Haute facilities of Commercial Solvents have capacity "in excess of 5 million lb./year"; may prove vital to missile fuel program

Present total U.S. capacity for production of methylamines is believed to be about 30 million lb./year (exact figure is classified for reasons of national security and published figures show only material sold on the open market). If new missile fuels containing these amines are mass produced for defense purposes, annual needs are estimated as high as 50 million lb./year, calculated as dimethylamine. Evidently, Commercial Solvent's new plant in Terre Haute, Indiana, whose capacity is given only as more than 5 million annual pounds, may well be needed to serve military as well as peacetime uses.

The new plant, entirely continuous, produces the amines by reacting methanol and ammonia catalytically at high temperatures and pressures. A mixture of mono, di, and trimethylamine is formed and subsequently purified by distillation. The whole unit is stated to be so completely instrumented and automatically controlled that one operator, plus a day-time, utility operator, can control and operate the plant. Figure 1 shows the typical flow sheet of such a plant. A number of different separation methods may be used, depending on conditions at any given plant location and on the product distribution desired. Design was by J. D. Leonard & Associates, New York.

In addition to missile fuels, the methylamines are being intensively studied as components of organo-metallic compounds, insecticides, and new photochemicals. Table 1 gives a summary of present uses of the three amines being made at the new Commercial Solvents plant.

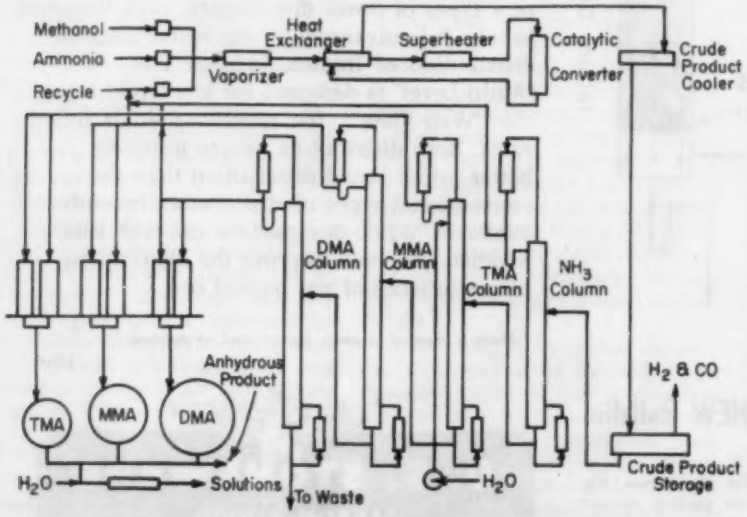


Figure 1—Typical flow scheme of continuous process for methylamines

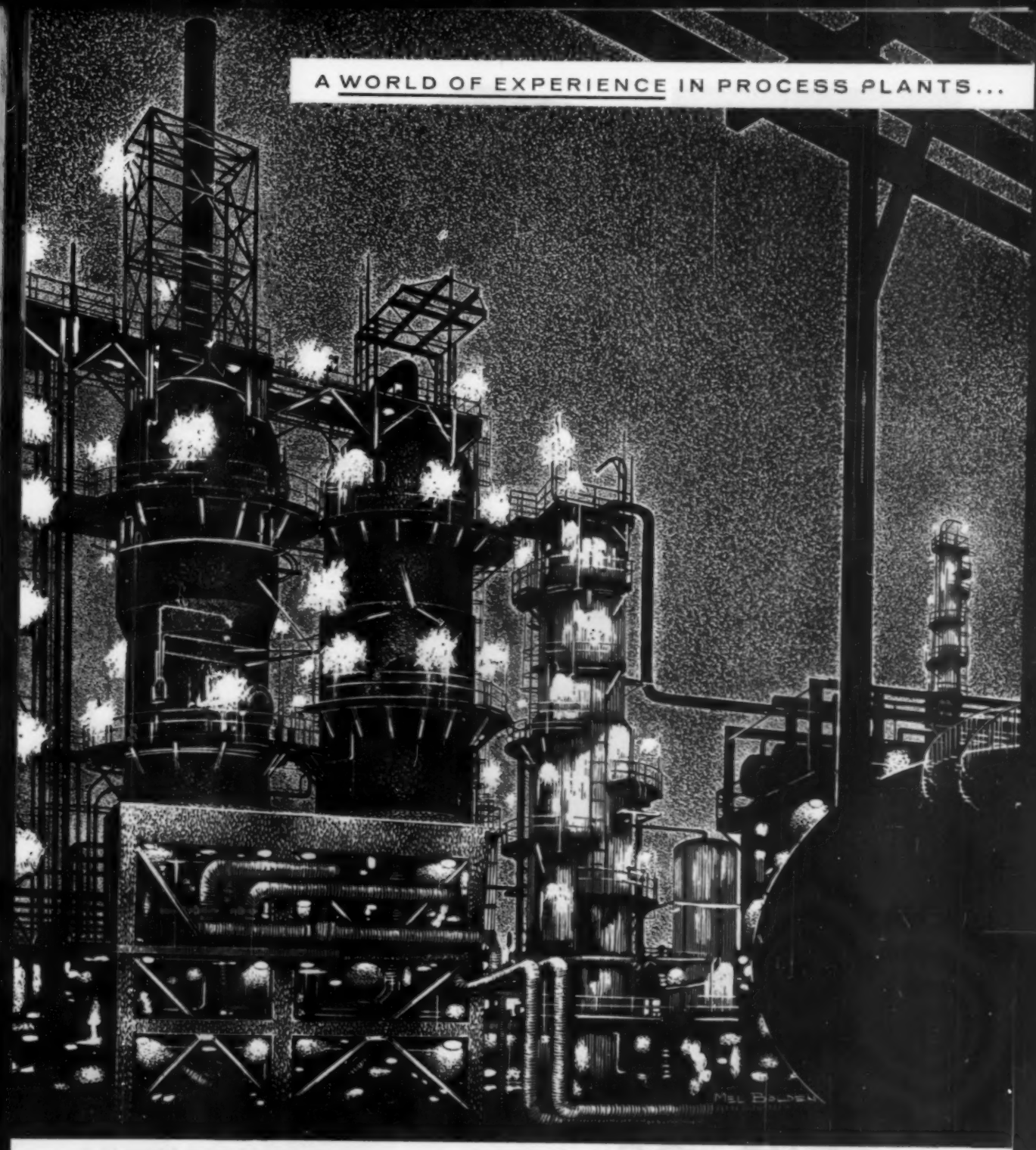
Ceramic-clad metal structures open new horizons in equipment fabrication

New process said to combine temperature, corrosion, and oxidation resistance of ceramic materials with structural strength of metals

A patent covering the electrophoretic deposition of metal and ceramic materials on a metal body by interposed graded coatings of ceramic materials has been granted to Vitro Corp. of America. In electrophoretic deposition, an electrostatic field is established between two electrodes immersed in a colloidal dispersion of charged particles, causing migration of the suspended particles to one of the electrodes. The particles produce an adherent coating on the electrode. The newly-developed process is said to offer exceptional uniformity of coating thickness and compactness as compared with conventional application methods. How is it done?

When a mixture of metallic oxides or ceramic materials are co-deposited on the surface of a metal body, and the oxides subsequently reduced to the metal by firing at high tempera-

continued on page 80



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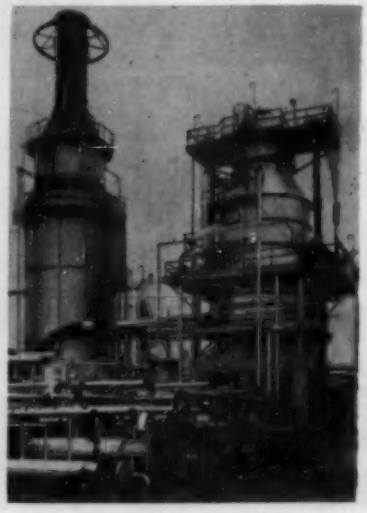
Ceramic-clad

from page 78

tures in a reducing atmosphere, a sintered metal matrix is formed which is chemically bonded to the metal body by matrix metal body co-diffusion across the common interface. The sintered ceramic materials are entrapped within the pores of the matrix, forming a "cermet" which retains the structural strength of the metal and the oxidation resistance of the ceramic at temperatures above 700°C. This external cermet surface is somewhat metallic. However, a second coating of ceramic materials can be electrophoretically deposited on the first coating and sintered at high temperatures to produce a cermet with an external surface composed entirely of refractory ceramic materials.

Metals and ceramic materials used depend on the intended application. Such metals as molybdenum, low-alloy steels, and tungsten are usually used for the bodies, with the reducible metallic oxides being chosen from the oxides of chromium, nickel, cobalt, or mixtures of these oxides. For the refractory ceramic materials, carbides, borides, and silicides are the usual choice.



A new vacuum unit at Ashland Oil & Refining's Canton, Ohio, Refinery has a two-fold goal; the combination heater (left) and vacuum tower (right) will produce feed stock for catalytic cracking into gasoline, and large quantities of asphalt in anticipation of the Federal Highway Program. Feed for the unit will be 15,000 barrels/day of bottoms from a crude unit. Design and construction were by Blaw-Knox.

PROCESS SIMULATION

What is it?

Process Simulation is a technique of equating electronically the operation of a given process whether chemical or petroleum.

Essentially it involves the use of analog computing equipment whose components can operate on d-c voltages in the same manner that a refinery operates on the material which it is processing.

Process Simulation, applied to a process design problem, provides the engineer with a miniature process plant at his fingertips, one which can be quickly and conveniently manipulated to operate in any way he chooses, either as it should, or even as it shouldn't.

The desirability of applying Process Simulation to your design problems can be quickly and economically explored at Electronic Associates, Inc. computation centers in Princeton, New Jersey; Los Angeles, California; and Brussels, Belgium.

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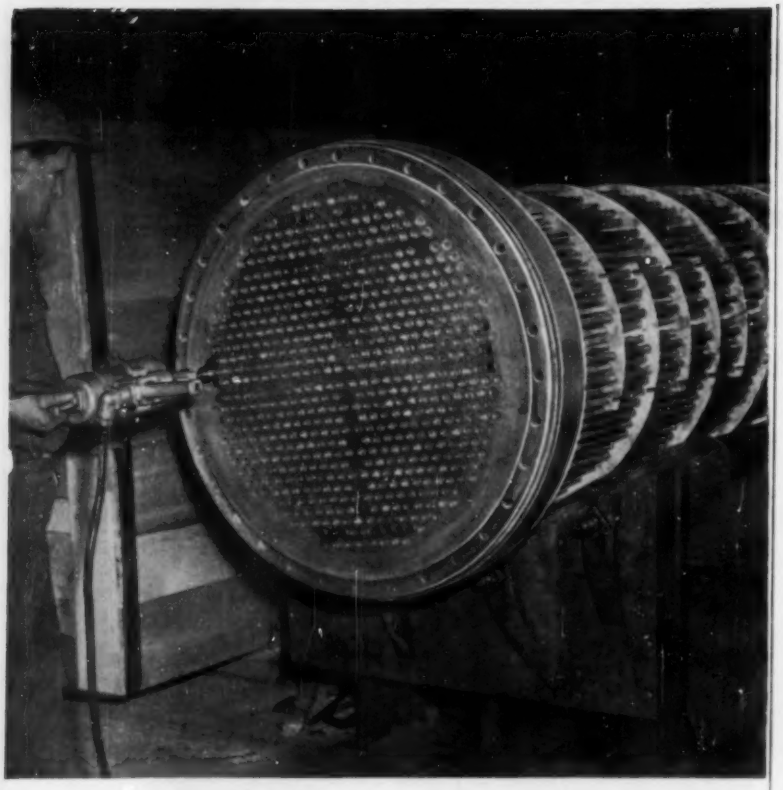

Tricky assembly job handled with ease...at Downingtown

Specs said: Roll type 329 stainless tubes into type 316 and 304 tube sheets. A tricky problem, since the 329 tubes are 15-20 points harder on the Rockwell B scale than the 304 and 316 tube sheets.

What's more, an alert suggestion saved our customer the cost of a test shell, by utilizing the annulus created by the specified double tube sheet construction.

Design Pressure: Shell —125 psi at 300° F.
Tubes— 75 psi at 300° F.
Hydrostatic Test Pressure: 150 psi
Construction: Per ASME Code, Para. U-69...Customer Inspected
Tubes: 608 Stainless Steel Tubes, Type 329 (Carpenter #7MO)
¾" O.D. x 16 ga. x 15' 9" L.
Outer Tube Limit: 30⅜"...4 Pass
Floating Tube Sheets: Two—1½" and 2" thick...32⅜" O.D.
Fixed Tube Sheets: Two—1¼" and 1¾" thick...38⅜" O.D.
Shell Side Tube Sheets: Stainless Steel, Type 304.
Tube Side Tube Sheets: Stainless Steel, Type 316.

Write for helpful heat exchanger design data—Bulletin HE.

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First private beryllium fabrication plant

Development of an extensive industry depends on continuing research and development to improve certain properties.

With startup of Beryllium Corporation's Hazleton, Pa. fabrication plant, beryllium has followed others of the so-called "rare" metals into commercial production. (Up to the present, the only such unit has been operated by the AEC.)

Fabrication of beryllium is a powder metallurgy process, since high-purity beryllium ingots, as presently produced, are too porous for fabrication by standard mill techniques. At Hazleton, cast ingots (from the adjacent Beryllium Corp. plant) are lathe chipped into small pieces, then ground to minus 200 mesh powder. The powder is transferred to a hot pressing vacuum furnace, where it is pressed to densities exceeding 95% of theoretical. The resulting pressings can be machined, extruded, or rolled by standard methods.

The development of an extensive fabrication industry is the next step in beryllium progress, believes Beryllium Corp. With a melting point of 2345°F, beryllium is the only light metal that will resist the high temperatures demanded for modern aircraft and certain chemical processing requirements. However, the main present barrier to more widespread use of the metal is lack of ductility. A major Air Force-sponsored development program is now underway to improve this characteristic.

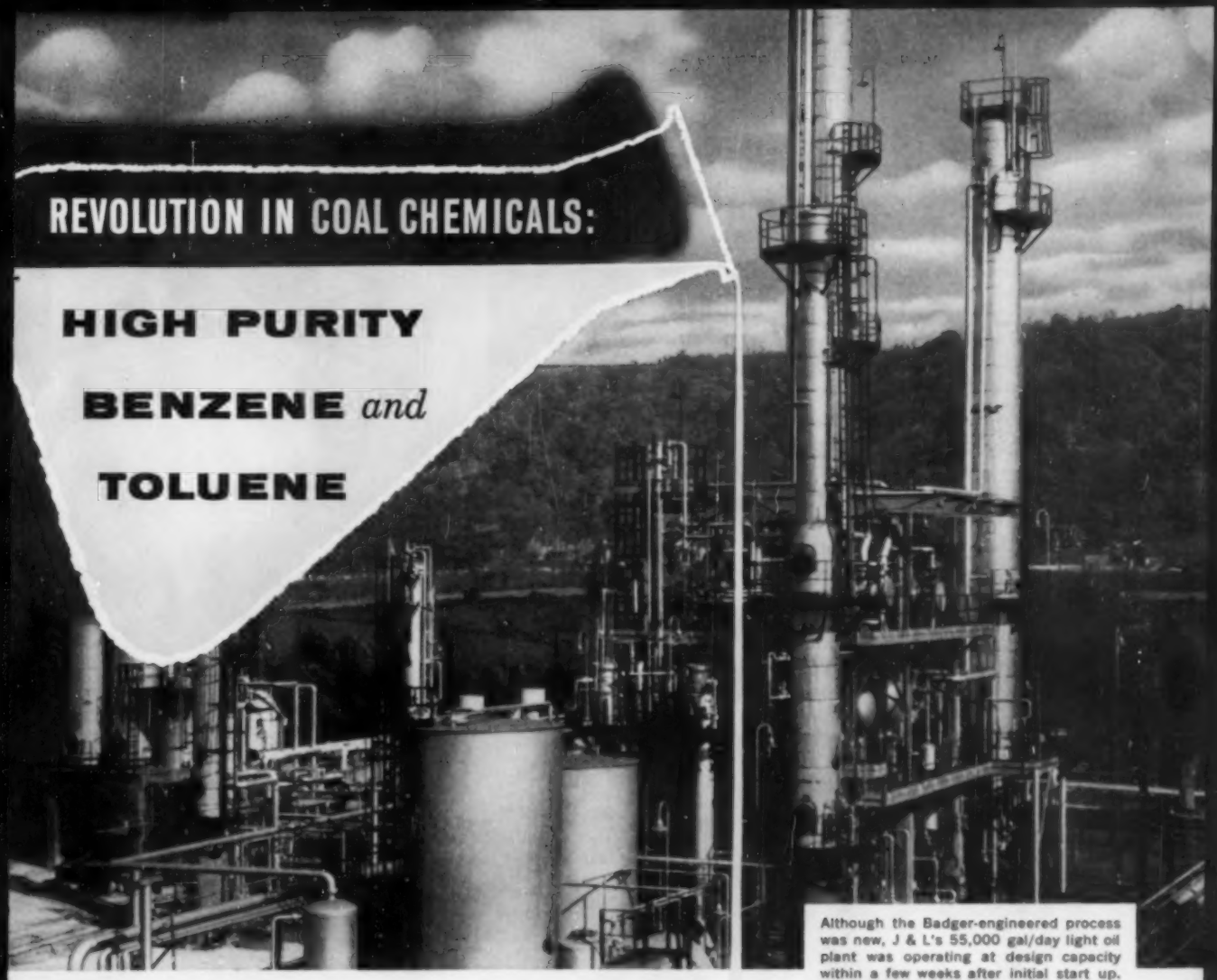
A plant to produce chlorinated hydrocarbons is planned for Southern California by American Chemical Corp., jointly-owned subsidiary of Richfield Oil and Stauffer Chemical. Preliminary design studies are being carried out by C. F. Braun. #

Liquid oxygen, nitrogen, and argon, at a rate of more than 30 tons per day will be coming from the new Los Angeles plant of National Cylinder Gas Division, Chemtron Corp. Production is scheduled for early 1959, cost is quoted at $1,750,000. #

Fabrication facilities for high-alloy, corrosion-resistant steels will be tripled at the Berea, Ohio, plant of Alloy Engineering Co. #

REVOLUTION IN COAL CHEMICALS:

HIGH PURITY BENZENE *and* TOLUENE



Although the Badger-engineered process was new, J & L's 55,000 gal/day light oil plant was operating at design capacity within a few weeks after initial start up. This plant marks the first time Esso's Hydrofining and Universal Oil Products Company's Udex processes have been adapted in combination for coal chemical operations.

Acid washing eliminated in new plant built for J&L by Badger

STEELMAKERS, saddled with conventional processes, have been hard pressed to satisfy market demands for near absolute purity benzene and toluene at low cost.

Jones & Laughlin Steel Corporation, looking for a solution to this critical problem, turned to Badger for engineering counsel. Their combined decision: A completely new type plant based on processes proven in other industries but new in coal chemical operations. Now on stream, J & L's new plant is producing benzene and toluene of higher purity than similar products derived from any other source.

What's more, this pioneering plant promises important operating economies. Hydrogenation has been substituted for the conventional acid washing step. This important process improvement not only increases amount of product recovered but also eliminates a source of high maintenance costs. Also, the plant and its controls are completely integrated with other process units for labor saving operation.

The broad experience of Badger Engineers — and their ability to use it in solving new problems — served J & L well. Many other clients, too, say such experience is a Badger difference that "makes the difference." Wouldn't it be wise to inquire how it could serve to make your engineering and construction projects more successful?

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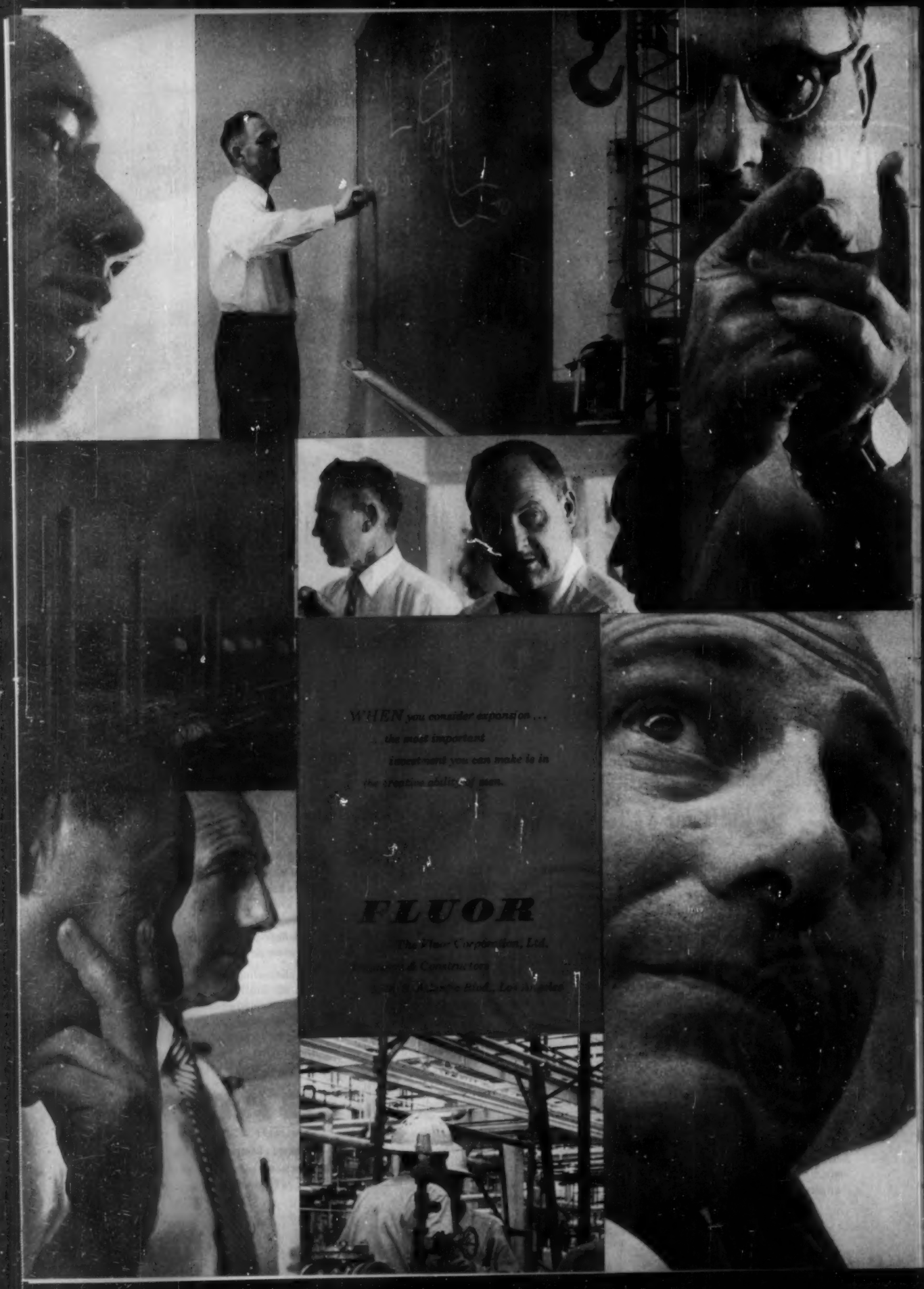
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Agitators, portable and tripod. Specification sheets from New England Tank & Tower Co. **Circle 102L-B.**

Agitators, side-entering. Bulletin 532 from New England Tank & Tower Co. **Circle 102L-D.**

Agitators, tank-top. Bulletin 551 from New England Tank & Tower Co. **Circle 102L-A.**

Agitator Kit, experimental. Bulletin from Chemineer, Inc. describes complete laboratory experimental agitator kit. **Circle 148L.**

Amplifier, wide-band. Bulletin from Arenberg Ultrasonic Laboratory gives complete technical details. **Circle 152L-B.**

Blending Systems. Technical data from Sprout-Waldron & Co. **Circle 127A-A.**

Castings. Technical data from Kutztown Foundry & Machine Corp. **Circle 159TL.**

Castings, high-alloy. Catalog gives complete selection tables for high-alloy castings. Duraloy Co. **Circle 145R.**

Contrifuges. Data from Sharples Corp. on the P-7000 Super-D-Center, the Super-D-Hydrator, and the DH-6 Nozljector. **Circle 106-107A.**

Coils, heating, Dean Products, Inc. Bulletin 355 with technical data and Bulletin 258 with price and design data. **Circle 167TR.**

Coils, heating and cooling. For corrosive air mixtures or gas, liquid heating

continued on page 88

MATERIALS

Bearing Material. Bulletin T-120 and Price Sheet 126 from Crane Packing Co. describes Chemloy 719, for use where lubrication is impossible, impractical or undesirable. **Circle 24L.**

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Equipment *continued from page 86*

or cooling. Technical data from Rempe Co. **Circle 159BL.**

Collectors, dust. Floor-mounted, available in 200 or 400 cu. ft./min. capacities. Details from Sprout-Waldron & Co. **Circle 127A-B.**

Controls, level, bin. Bin-Dicator prevents bin overflow, conveyor clog, elevator choke-up, machinery damage, repair shut-down. Catalog BD-15 from Bin-Dicator Co. **Circle 160BL.**

Conveyors, bulk chemicals, Dust-free, sanitary operation, conveys hot materials up to 1,200°F. Data from Buhler Brothers, Inc. **Circle 154L.**

Coolers, after. Bulletin 130 from Niagara Blower Co. **Circle 30BL.**

Couplings, quick. Available in stainless, aluminum, malleable iron, brass. Full details from Ever-Tite Coupling Co. **Circle 14A.**

Crushers. General Catalog 56 from Bauer Bros. Co. **Circle 150BR.**

Cryogenic Systems. Consulting Services available from Air Products, Inc. on any type of low-temperature process requirements. **Circle 125A.**

Desuperheater. Complete details on four types available from Schutte and Koerting Co. Bulletin 6D. **Circle 31A.**

Distributors, tower. U. S. Stoneware offers details of two types of distributors designed for use with Intalox Saddles. **Circle 77A.**

Dryers, air. Electric or steam regeneration dryers — automatic, semi-automatic, or manual operation. Pressures to 5,000 lb./sq. in. Complete data from Kahn and Co. **Circle 148BR.**

Dryers, drum. Test evaluation offered on pilot scale models. Goslin-Birmingham Mfg. Co. Details. **Circle 22L-A.**

Dryers, vacuum, "Rota-Cone." No contamination or degradation of the most delicate materials. Illustrated folder from Paul O. Abbe Inc. **Circle 124L.**

Dryers, vacuum rotary. Test evaluation on pilot scale models. Goslin-Birmingham Mfg. Co. **Circle 22L-B.**

Dryer-Blenders. Pfaudler Co. offers technical details of its line of conical dryer-blenders. **Circle 28A-A.**

Drying Systems. Molecular Sieve drying systems available in any size with either single or multiple beds. Data from Linde Co. **Circle 112L.**

Ejectors, gas. No moving parts. Bulletin 9013-A from Ingersoll-Rand. **Circle 168L.**

Ejectors, steam-jet. Free consulting service from Graham Mfg. Co. **Circle 108L.**

Equipment, high-pressure. New 125-page catalog from American Instrument Co. describes valves, fittings, tubing, compressors, vessels, gauges, etc. **Circle 30TL.**

Equipment, process. Pfaudler Co. offers Buyers Guide. **Circle 28A-B.**

Equipment Components, corrosion-proof. Hoods, ducts, stacks, tank covers, flat sheets, cementing kits. Catalog sheets from Heil Process Equipment Corp. describe standard parts. **Circle 161L.**

Feeders, bulk materials. Available with automatic timing controls. Technical data from B. F. Gump Co. **Circle 3R.**

Feeders, chemical. Tank, agitator, and pump combined in one unit. Technical details from Neptune Pump Mfg. Co. **Circle 153BL.**

Feeders, gravimetric. Accurate, electronic-controlled, continuous flow feeding by weight. Catalog from Syntron Co. **Circle 163R.**

Filters. Eimco Corp. offers details of continuous vacuum and pressure drum, disc, pan, plate and frame, other types of specialized filters. **Circle 36A.**

Filters, laboratory, cylinder type. Details from Ertel Engineering Corp. **Circle 160BR.**

Filter Test Leaf, precoat. Allows study of all process variables of precoat filtration in the laboratory. Details from Dicalite Dept., Great Lakes Carbon Corp. **Circle 99A.**

Filtration Equipment. Data from Industrial Filter & Pump Mfg. Co. describes all types of industrial filters and filter systems. **Circle 92-93A.**

Flakers. Test evaluation offered on pilot-scale models by Goslin-Birmingham Mfg. Co. **Circle 22L-C.**

Furnaces, industrial, radiant. About 75% of heat to batch supplied by radiation from furnace walls. Details from Blaw-Knox, Chemical Plants Div. **Circle 105A.**

Gauges. Precision gauges available in wide range of case styles, case sizes, pressure ranges, materials. Catalog 1819 from United States Gauge. **Circle 151R.**

Grinders, fine. Illustrated bulletin from Gruendler Crusher & Pulverizer Co. **Circle 160TL.**

Heads, safety. For use when pressure-relief requirement is greater than the safety capacity of a valve. Technical data from Black, Sivalls & Bryson, Inc. **Circle 26L.**

Heat Exchangers. Bulletin HE from Downingtown Iron Works gives helpful heat exchanger design data. **Circle 82L.**

Heat Exchangers. Bulletin 158-HE from Doyle & Roth Mfg. Co. describes full line of standardized exchangers. **Circle 136L.**

Heat Exchangers. "Aero" heat exchangers are practically independent of water supply. Details from Niagara Blower Co. Bulletin 132. **Circle 162BR.**

Ion Exchange Equipment. For removing organic matter, hardness, alkalinity, turbidity, color, etc. Technical data from Illinois Water Treatment Co. **Circle 150L.**

Joints, ball. Bulletin 31 from Barco

continued on page 90

Materials *from page 86*

Linings, pipe. Fluoroflex-T is completely inert to all corrosives, including hydrofluoric acid. Bulletin TS-1A from Resistoflex Corp. gives details. **Circle 34A.**

Packing, pump and valve. Bulletin AD-155 from United States Gasket gives data on Teflon packing for pumps and valves. **Circle 8L.**

Packing, Teflon. Recommended for concentrated alkalies and acids. Maximum temperature range of 500°F. Brochure from Flexrock Co. **Circle 167BR.**

Porcelain, chemical. For acid and abrasion-resistant service. Description and specifications from Lapp Insulator Co. **Circle 23A.**

Sodium Hydride, dispersions in oil. Research indicated that many ketones can be condensed with sodium hydride in oil and ethyl chloroacetate. Details from Metal Hydrides, Inc. **Circle 25A.**

Sodium Hydride, dispersions in oil. Brochure titled "Sodium Dispersions" from U. S. Industrial Chemicals, describes preparation of sodium dispersions in oil. **Circle 19-20A.**

Tantalum Test Kit. Corrosion test kit, available without charge to research technicians, contains tantalum sheet and wire. For information, **Circle 147R.**

Services *from page 86*

isville Dryer Div., General American Transportation will study your materials and needs, recommend type of equipment, size, and heating medium. Details. **Circle 103A.**

Fabrication, process equipment. Design and fabrication to all codes. Details from Manning & Lewis Engineering Co. **Circle 12L.**

Fabrication, process equipment. Dryers, coolers, furnaces, reactors, presses, pilot plants. Data from Edw. Renneburg & Sons Co. **Circle 134L.**

Fabrication, process equipment. Engineering, research, and fabricating services for any type of equipment. Data from Struthers Wells, **Circle 27A.**

Fabrication, process equipment. In stainless, aluminum, Monel nickel, Inconel, all clad materials, nickel plated steel. Bulletin 550 from Koven Fabricators, Inc. **Circle 155R.**

Fabrication, process vessels. Wyatt Metal & Boiler Works, Inc. **Circle IFC.**

Fabrication, special equipment components. Data memorandum 23 from Superior Tube describes facilities and services. **Circle 9A.**

Process Simulation. Data from Electronic Associates, Inc. on electronic simulation of chemical processes. **Circle 81A.**

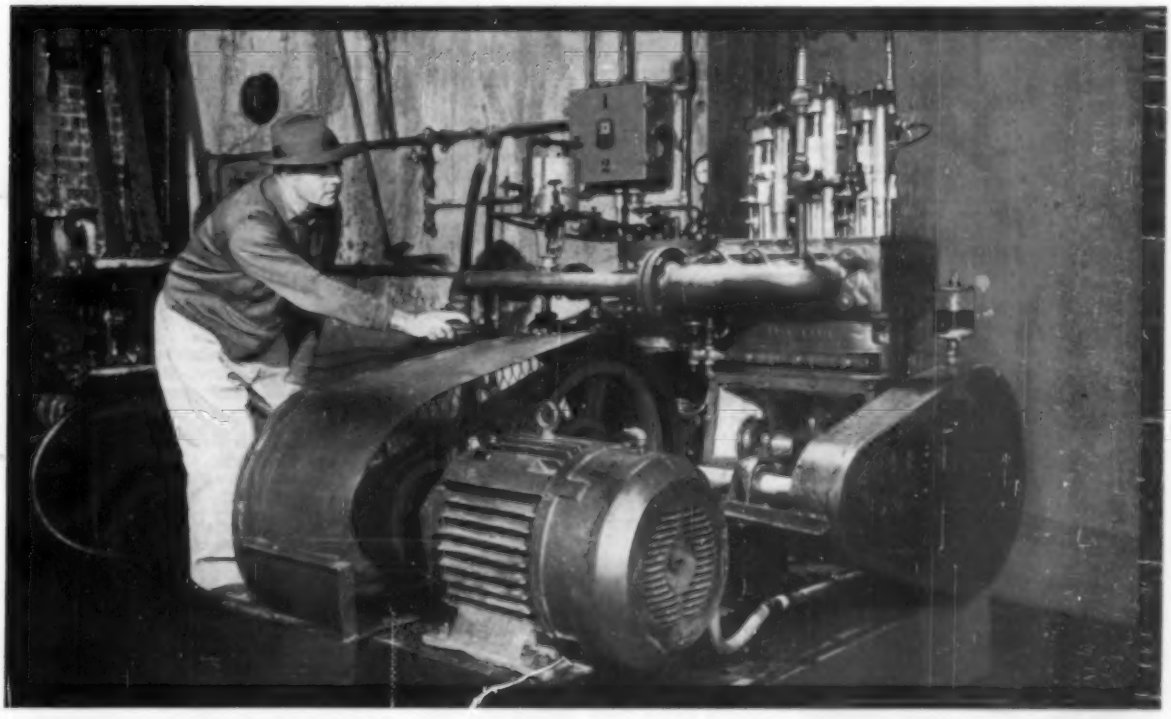
MISCELLANEOUS

Automobiles. Oldsmobile Division, General Motors Corp. **Circle 149A.**

JACQUES WOLF & CO. SOLVES PROBLEM:

How to maintain constant, undeviating pressure in the production of highly corrosive chemicals

Precise, non-fluctuating pressures must be maintained in continuous processes at the Carlstadt plant of Jacques Wolf & Company. Erratic pressure caused by drop in volumetric efficiency could ruin an entire batch of costly material.



How Jacques Wolf solved the puzzle: Looking for an answer to the problem of holding constant pressure, plus that of increasing production, Jacques Wolf called on Aldrich. Aldrich engineers designed a pump which provided the proper corrosion resistance, fluid velocity and wear characteristics to insure dependable, continuous operation.

Result: After five months of use, the Aldrich Triplex Pump has met all guarantees and proven itself capable of continuous operation. Working 24 hour days, 6 day weeks, the Aldrich Triplex Pump provides the necessary pressure without fluctuation, efficiently handling both alkaline and acidic materials.

We'll be glad to send you full information on Aldrich Pumps and their advantages to you. Simply write Aldrich Pump Company, 20 Gordon Street, Allentown, Pa.

the toughest pumping problems go to ALDRICH

Mfg. Co. contains diagrams showing solution of many common pipe expansion problems. **Circle 126L.**

Joints, expansion. Technical data from Yuba Consolidated Industries on ADSCO Corruflex expansion joints. **Circle 137A.**

Mixers. Catalog A-27 from Philadelphia Gear Corp. gives all information needed to make catalog selection of complete mixer assembly. **Circle 32A.**

Mixers. Condensed catalog from Mixing Equipment Co. describes all types. Bulletin 109. **Circle OBC-F.**

Mixers, laboratory and small-batch. Bulletin 112 from Mixing Equipment Co. **Circle OBC-E.**

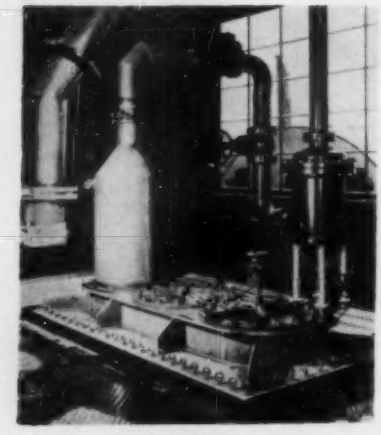
Mixers, pipeline. Bulletin 531 from New England Tank & Tower Co. **Circle 102L-C.**

Mixers, portable. ⅛ to 3 hp. Bulletin 108 from Mixing Equipment Co. **Circle OBC-C.**

Mixers, side-entering. 1 to 25 hp. Bulletin 104 from Mixing Equipment Co. **Circle OBC-D.**

Mixers, top-entering. Propeller types: ¼ to 3 hp. Bulletin 103 from Mixing Equipment Co. **Circle OBC-B.**

DEVELOPMENTS OF THE MONTH



SPECIAL HORIZONTAL BATCH MIXER

(Circle 428 on Data Post Card)

All metal parts in contact with the material to be processed are made of nickel in a special horizontal batch mixer fabricated by Sprout-Waldron for Dow Chemical. The unit is used in the mixing of thermoplastic materials and formulations.

The mixer has a swept volume capacity of approximately 58 cu. ft., and is designed to handle a 3,000 lb. batch of material. It is jacketed for 30 lb./sq.in. gauge working pressure, and contains internal baffles to prevent short circuiting.

Mixing is accomplished by means of a double-ribbon agitator with end stubs set in anti-friction pillow blocks. For further details of this type of mixer, circle 428 on Data Post Card.

Mixers, top or bottom-entering. Turbine, paddle, and propeller types: 1 to 500 hp. Bulletin 102 from Mixing Equipment Co. **Circle OBC-A.**

Noise Control Devices. Complete catalog from Pulsation Controls Corp. describes blowdown mutes, shock traps, exhaust, suction, and burner mutes. **Circle 120L.**

Nozzles, spray. Catalog 5600 from Binks Mfg. Co. gives applications, sizes, capacities, spray patterns, and materials of construction, selection tables. **Circle 146L.**

Nozzles, spray. Complete catalog from Spray Engineering Co. **Circle 143R.**

Nozzles, spray. Wide range of types and capacities. Catalog 24 from Spraying Systems Co. **Circle 166BL.**

Oscillator, pulsed, high-power. Bulletin from Arenberg Ultrasonic Laboratory. **Circle 152L-A.**

Packing, tower. Comprehensive booklet discusses application of Tellerettes (polyethylene packing) to tower use. Harshaw Chemical Co. **Circle 129A.**

Packings, tower. Raschig rings, single and double partition rings, Berl saddles, Tellerettes (polyethylene). Knox Porcelain Corp. **Circle 142BL.**

Piping, corrosion-resistant. Comprehensive Bulletin 20 from Fibercast Co. gives engineering data and charts, chemical resistance data, specifications, installation procedure. **Circle 158L.**

Processor, "Turba-Film." Specially designed for process situations involving mechanically-aided heat transfer. Details from Rodney Hunt Machine Co. **Circle 109A.**

Presses, "floating cone." Continuous automatic control of liquid or solids recovery. Full details from E. D. Jones & Sons Co. **Circle 161R.**

Pumps. Technical data on all types of pumps for the chemical process industries. Aldrich Pump Co. **Circle 89A.**

Pumps, controlled-volume. Up to ten liquid ends can be connected to one variable speed drive. Details from Milton Roy Co. **Circle IBC.**

Pumps, impervious graphite. Three new sizes of Karbate impervious graphite pumps now available from National Carbon Co. Technical details. **Circle 91A-C.**

Pumps, leakproof. Pump and motor in single leakproof unit. No shaft sealing device. Handles fluids at temperatures to 1,000°F., pressures to 5,000 lb./sq. in. Details from Chempump Corp. **Circle 95A.**

Pumps, sealless, plastic. Available in wide range of plastic and synthetic materials. Bulletin 901 from Vanton Pump and Equipment Co. **Circle 97A.**

Pumps, vacuum. Bulletin 95 from Beach-Russ Co. gives technical details of combination two-stage vacuum pumps. **Circle 140R.**

Pumps, vertical. Bulletin B-1700 gives complete technical details of the Hydro-Line vertical pump line, made by Peerless Pump Div., Food Machinery and Chemical Corp. **Circle 133A.**

Recorders, control stations. Bulletin 13-18 from Foxboro Co. gives full details on Consotrol Recording Control Stations. **Circle 10-11A.**

Rectifiers, mercury-arc. Bulletin 12B-8494 from Allis-Chalmers gives detailed technical information. **Circle 13A.**

Rotameters. Bulletin from Schutte and Koerting describes "Safeguard" rotameters with PVC end fittings, gives instructions for liquid and gas sizing, list of fluids for which PVC is recommended. **Circle 157R.**

Screens. Bulletin 26C6177M from Allis-Chalmers gives valuable screen selection data. **Circle 115A.**

Scrubbers, fume, jet-Venturi. Complete catalog from Croll-Reynolds Co. **Circle 29A.**

Scrubbers, gas, high-velocity. For high efficiency removal of sub-micron particles. Technical data from Peabody Engineering Corp. **Circle 104L.**

Separators, entrainment. Complete technical data on the Yorkmesh Demister from Otto H. York Co. **Circle 4A.**

Sifters, gyro. Details from Sprout-Waldron & Co. **Circle 127A-C.**

Sifters, vibrating. Information on specific applications from Read Standard Division of Capitol Products. **Circle 119A.**

Thermocouple Wells. Bulletin 2000 gives specifications, size, ordering information on Serv-Rite drilled wells. Claud S. Gordon Co. **Circle 153R.**

Tubes, filter, porous carbon. Any I.D. and O.D. up to 6⅝ in., lengths up to 36 in. Sizes and prices from National Carbon Co. **Circle 91A-B.**

Valves, miniature. All types of miniature valves for pilot and process plants. Data from George W. Dahl Co. **Circle 131A.**

Valves, nickel and Monel. Technical data from Wm. Powell Co. on complete line. **Circle 21A.**

Valves, reducing. Inlet pressures from 7 to 250 lb./sq. in.—reduced pressure ranges from 2 to 35 lb./sq. in. Complete capacity-regulation data from Leslie Co. **Circle 121A.**

Vessels, pressure. Fabrication of any size, type, in any metal. Technical data from Posey Iron Works. **Circle 156B.**

Viscometers. Technical data from Brookfield Engineering Laboratories. **Circle 118L.**

Waste Disposal Systems. Free 40-page booklet from Dempster Brothers on "How to Cut Waste Disposal Costs." **Circle 117A.**

Waste Disposal Units. Custom-designed for individual applications. Data from John Zinc Co. **Circle 132BR.**

News from
National Carbon Company
Division of Union Carbide Corporation · 30 East 42nd Street, New York 17, N. Y.
Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. IN CANADA: Union Carbide Canada Limited, Toronto

National Carbon representatives expand your Engineering Force

S. J. MILLER—SALES ENGINEER

After graduation from Massachusetts Institute of Technology with a BS degree in Chemical Engineering, Miller spent five years in process design and production supervision, including equipment specifications, economic evaluations of processes, and plant start-ups.

Miller has been a Sales Engineer with National Carbon Company since 1953. Knowing chemical plant corrosion problems from actual experience, Steve Miller is well equipped to assist engineers and plant operators on the application, design and installation of carbon, graphite and "Karbate" impervious graphite process equipment.

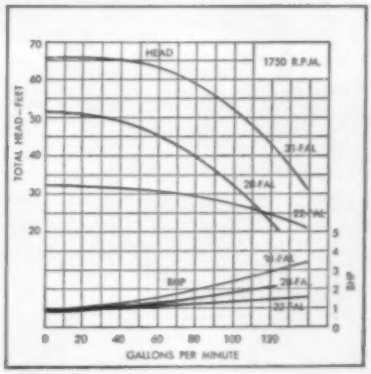
New Activated Carbon finds extensive use!

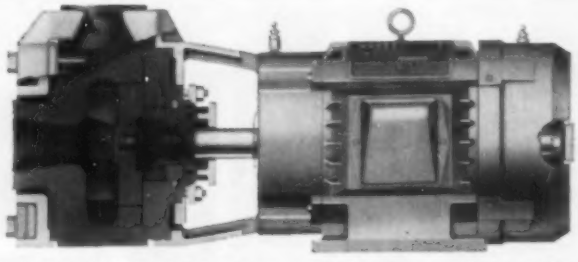
A new grade of "Columbia" activated carbon for use as a catalyst support material has been developed by National Carbon Company. Combining high activity, strength and porosity, the new grade CXC 4/6 is priced at half that of the well-known grade CXAL 4/6 it replaces. Grade CXC 4/6 is expected to give better performance than previous grades in a wide variety of additional uses. It is available in the form of 3/16" diameter pellets. For details, write National Carbon Company.

"KARBATE" PUMP LINE EXPANDED!

Three new sizes of Model F Centrifugal Pump extend Capacity and Head

Three new sizes of Model F "Karbate" impervious graphite pumps are now available to meet the demands of the chemical and metal finishing industries for greater capacities and heads. These are designated as Sizes 22-FAL, 28-FAL, and 31-FAL. Operating at 1750 RPM, capacities up to 150 GPM and heads up to 67′ can be obtained. To handle fluids with specific gravities greater than water at the higher capacities and heads, the 28-FAL and 31-FAL pumps are available with 3 and 5 horsepower motors. The chart on the right shows performance curves for the new Model F "Karbate" centrifugal pumps.





Model F "KARBATE" Pump withstands rough handling

A Model F "Karbate" impervious graphite pump has operated successfully for three years in a large refinery's portable equipment cleaning unit. The "Karbate" impervious graphite parts of the pump withstood the abuse normally encountered in this type of service. However, when changing the seal, the steel support casting was damaged. The body bolts were tightened so hard that the pressure broke the casting. The "Karbate" volute case and cover were not even chipped. Here is proof that "Karbate" impervious graphite pumps are built to "take it" and that the armored design minimizes the possibility of damage even under the most severe operating and poorest maintenance conditions.

Porous Carbon Filter Tubes available from National Carbon Company

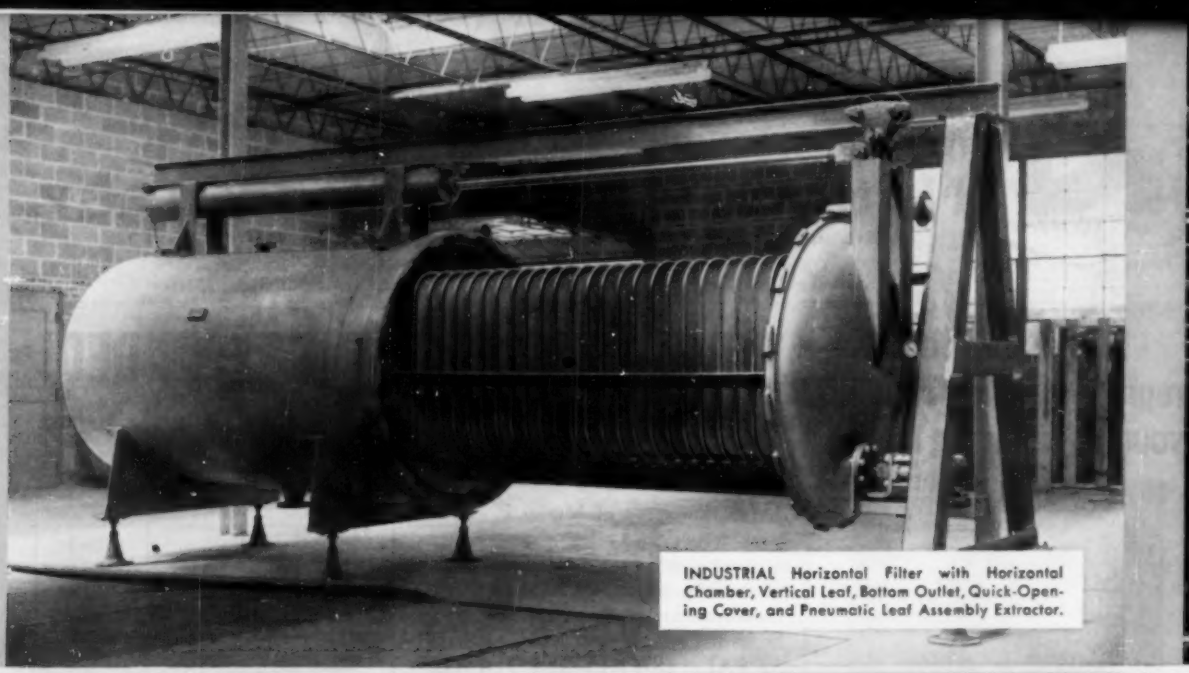
National Carbon Company can produce and supply all styles of porous carbon filter tubes for tube type filtering equipment. Tubes having any I.D. and O.D.'s up to 6⅝" with lengths up to 36" can be manufactured from available stock. In addition, Grade 40 porous carbon filter tubes, Style B, 2⅛" I.D. x 4½" O.D. x 36" long are in stock for immediate delivery. Sizes and prices of porous carbon filter tubes will be supplied upon request.

STYLE A STYLE B STYLE C STYLE D

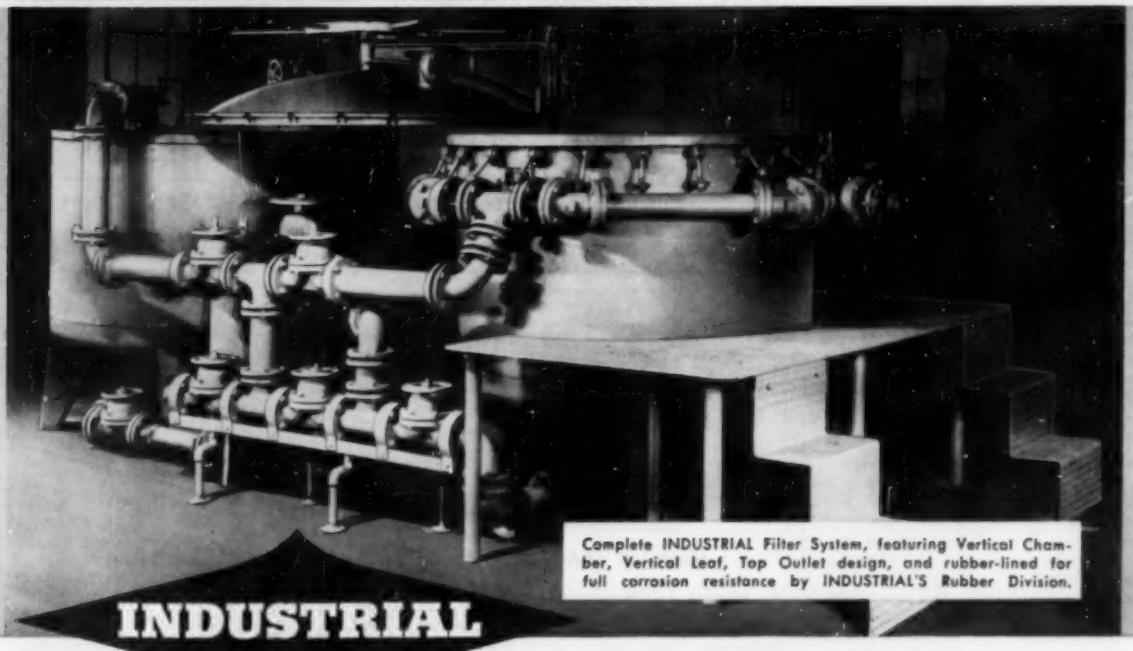
NATIONAL TRADE-MARK

The terms "National", "Columbia", "N" and Shield Device, "Karbate" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

UNION CARBIDE



INDUSTRIAL Horizontal Filter with Horizontal Chamber, Vertical Leaf, Bottom Outlet, Quick-Opening Cover, and Pneumatic Leaf Assembly Extractor.



Complete INDUSTRIAL Filter System, featuring Vertical Chamber, Vertical Leaf, Top Outlet design, and rubber-lined for full corrosion resistance by INDUSTRIAL'S Rubber Division.

INDUSTRIAL

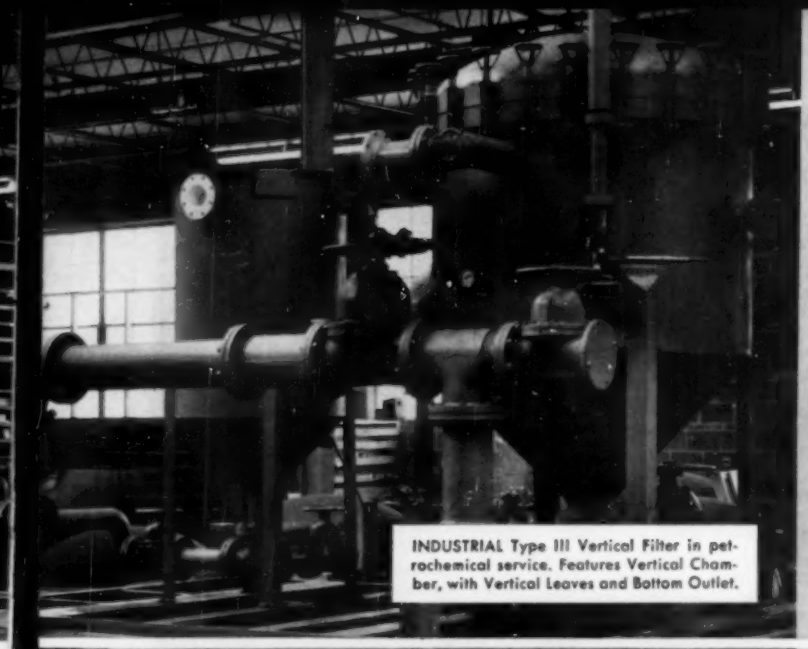
Engineered Filtration Equipment and Techniques to improve product quality—cut processing costs

Your process is different in some ways from any other. That's why—for highest product quality, operating simplicity, and economy—you need a filtration system built specifically for you. An INDUSTRIAL *engineered* system is exactly that.

INDUSTRIAL is more than a builder of filtration equipment—it's a specialized engineering service that makes available to you over 25 years of filtration experience and techniques. Our engineers and chemists will work with you to develop a system which takes into consideration all the factors vital to your specific operation—type of slurry, filter design, cake recovery, cleaning, piping, auxiliary apparatus, and controls. At INDUSTRIAL'S Testing Center, there are complete facilities for pilot plant study of any system, ready to be put to work for you.

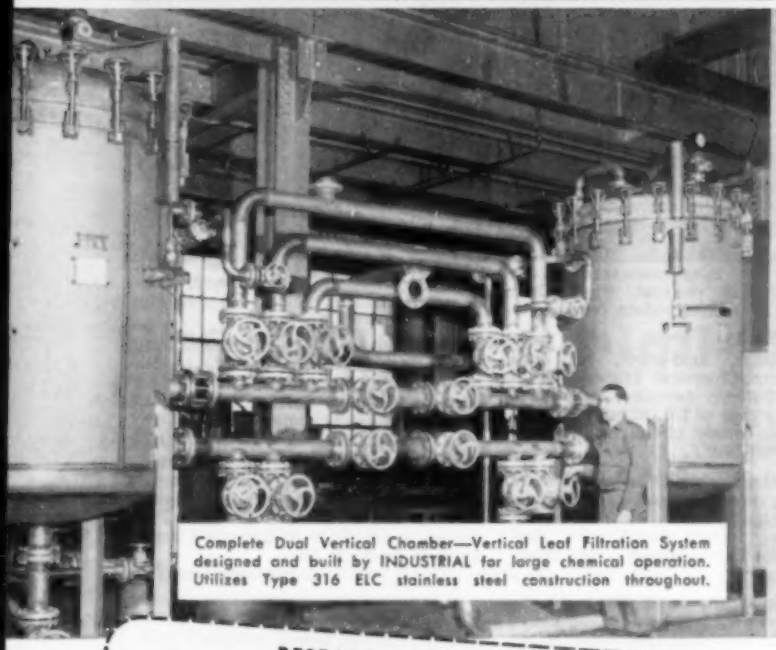
Remember, too, that INDUSTRIAL produces a full range of filter types and sizes—and can therefore recommend, without partiality, a filter most suitable for your needs. A wide variety of cost-saving optional features are also available. And all systems are adaptable to full or partial automation.

Call or write INDUSTRIAL to find out how properly-engineered filtration equipment and techniques can improve product quality and cut processing costs.



INDUSTRIAL Type III Vertical Filter in petrochemical service. Features Vertical Chamber, with Vertical Leaves and Bottom Outlet.

INDUSTRIAL Type 117 "Cyclamatic" Filter, provides continuous uninterrupted flow, and sub-micron particle removal without excessive pressure drop.



Complete Dual Vertical Chamber—Vertical Leaf Filtration System designed and built by INDUSTRIAL for large chemical operation. Utilizes Type 316 ELC stainless steel construction throughout.

Quick-opening bottom-drop door, through which filter cake is removed in seconds, is an outstanding feature of this INDUSTRIAL Vertical Filter.

RESEARCH AND DEVELOPMENT TESTING CENTER

Here, your process conditions can be duplicated and studied —to help you select the most suitable filtration system, without disturbing your production. This Center includes all types of pressure filters and auxiliary equipment—all interconnected by an ingenious valve and piping system. Comparative data on variations is obtained in minutes, instead of days of costly experimentation in your own plant.

Write today for descriptive literature and recommendations on INDUSTRIAL equipment to meet your specific requirements.

INDUSTRIAL

C358

INDUSTRIAL FILTER & PUMP MFG. CO.

5910 Ogden Avenue, Chicago 50, Illinois

PRESSURE FILTERS ◆ ION EXCHANGE EQUIPMENT ◆ WASTE-TREATING EQUIPMENT

CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD, PAGE 9

EQUIPMENT

301 Adsorption Device, hydrocarbon vapors. The Vape-Sorber, product of Selas Corp. of America, provides clean, dry air and gas for chemical manufacture and ammonia plants. Available in 14 standard sizes. Technical data.

302 Blowers, rotary-positive. New 20-page bulletin from Sutorbilt Corp. gives full technical details on continuous-service rotary positive pressure blowers, gas and vacuum pumps. Operating principles and list of applications.

303 Collectors, dust, mechanical. Two new designs of multiple-tube type mechanical dust collector are announced by Research-Cottrell. Technical data.

304 Compressors, air and gas, high-pressure. Catalog 44 from Norwalk Co. gives full details of multistage, booster and special compressors, vertical compressors. Useful conversion tables.

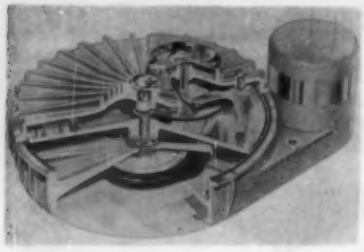
305 Computers, digital, control. Description of the RW-300 digital control computer, discussions of process control, data logging, pilot plant, and test facility applications for computer control systems. Brochure from Thompson-Ramo-Wooldridge Products Co.

306 Condensers, barometric. Bulletin covers theory, design features, construction, operation, application of barometric condensers for removing air, exhaust steam, and other vapors from vacuum equipment. Schutte and Koerting Co.

307 Controls, automatic. Catalog (52

continued on page 96

DEVELOPMENTS OF THE MONTH



DYNAMIC MEMORY PROCESSOR

(Circle 429 on Data Post Card)

A new memory processor unit said to have digital computer capability with analog simplicity has been introduced by Genesys Corp. In form, it is a hermetically sealed eight-inch diameter disc which can be used either as a basic element in advanced control computer systems, or as a nucleus memory unit in itself.

The disc is designed with two recording modes: one mode uses fixed channels for variations of digital computation and control; the other uses a scanning head channel for data processing and correlative control.

The unit is expected to find many applications in automation of refinery and chemical plant operations such as control of fractionation towers and catalytic crackers. For more data on this new development, circle 429 on Data Post Card.

MATERIALS

398 Alloy, brazing, nickel-base. Engineering data sheet from Wall Colmonoy Corp. describes properties and applications of Nicrobraz 50, intended for high-temperature service.

399 Brick, fire and insulating. Eight-page brochure from Johns-Manville gives selection tables with correct balance of thermal and physical properties for every application.

400 Carbon, activated. New grade specially developed for use as a catalyst support available from National Carbon Co. Technical data.

401 Chemicals, coal-tar. Reilly Tar & Chemical Corp. offers new edition of its index of coal-tar chemicals. Included are acetylenic alcohols, fused ring heterocycles, hydrocarbons, phenol and substituted phenols, and pyridine and pyridine derivatives.

402 Chlorides, metallurgy. Comprehensive 36-page booklet titled Chloride Metallurgy is available from Stauffer Chemical Co. Gives properties, uses, and reactions of aluminum chloride, antimony trichloride and antimony pentachloride, boron trichloride, silicon tetrachloride, titanium tetrachloride and titanium trichloride, and zirconium tetrachloride.

403 Chloroacetaldehyde. Properties, reactions, and uses discussed in revised technical manual from Dow Chemical Co. Includes data on toxicity and handling.

404 Coatings, acid-proof, for concrete. Electro-Chemical Engineering & Mfg. Co. Bulletin describes properties and applications of Duro-Crete, claimed resistant to many chemicals at temperatures to 212°F.

405 Coatings, protective. Humble Oil & Refining offers complete guide to industrial color systems. Includes safety code, piping system identification, suggested color combinations, color selection guide.

406 Hypochlorite, solutions. Technical bulletin from Pennsalt Chemicals, Pennsalt of Washington Division, gives complete details of the automatic continuous manufacture of hypochlorite solutions.

407 Insulation, pipe. Eight-page folder on new lightweight glass fiber pipe insulation for temperatures from subfreezing to 350°F. Physical properties, thermal conductivity, application guide. L.O.F. Glass Fibers Co.

408 Insulation, wire and cable. Handbook of butyl insulation from National Electric Products Corp. Many charts and listings of technical data.

409 Jacketing, aluminum. Manual on aluminum insulation gives recommended jacketing materials and methods. Application specifications, corrosion resistance of aluminum alloys, jacketing computation tables. Kaiser Aluminum & Chemical Sales, Inc.

410 Perchloryl Fluoride. Technical data from Pennsalt Chemicals on perchloryl fluoride with emphasis on its utility as a rocket fuel oxidizer. 24-page booklet on properties, handling, storage, plus data sheet on propellant applications.

411 Polyethylene. Use of emulsifiable polyethylene as a textile finishing agent described in new 16-page booklet from Semet-Solvay Petrochemical Division, Allied Chemical Corp.

412 Polyphenyls. Brochure from Monsanto Chemical gives physical properties of nine organic chemical fluids (polyphenyl compounds and certain of their alkyl derivatives), which exhibit outstanding resistance to radiation and thermal damage.

413 Polypropylene. Technical bulletin from Hercules Powder Co. discusses commercial applications, gives information on processing and fabrication.

414 Resins, ion-exchange. Data sheet and price list from Bio-Rad Laboratories gives technical data on specially-refined analytical grade ion-exchange resins.

415 Resins, polyester. American Cyanamid offers technical data sheet on new polyester resin, Laminac 4106, rigid in type, with medium reactivity, and low thixotropic viscosity.

416 Silicon Nitride. Resists molten aluminum, other non-ferrous metals; resists corrosion, retains strength above 2,000°F; withstands thermal shock; available in many shapes and sizes. Complete data in bulletin from Haynes Stellite Co.

417 Silicone Fluids. Dow Corning offers "An Engineering Guide to Silicone Fluids for Mechanical Applications." Many tables, graphs, much other engineering data.

418 Silicone Gums, vinyl-modified. Designed for use in formulation of Class 500 or extreme low-temperature service silicone rubber compounds. Product information and sample formulations available from General Electric, Silicone Products Dept.

continued on page 98

SERVICES

424 Design and Construction, Girbotal process plants. New booklet from Girdler Construction Div., Chemtron Corp., gives performance data on typical industrial applications.

425 Drying Service. Facilities for drum drying solutions of starches, resins, etc., now available to chemical processors on a contract production basis from Morningstar-Paisley, Inc.

426 Filtration Media Testing Service. Complete testing service, including report with test results, recommendations, specifications, and samples of suggested filtration media. Information from Snow Filtration Co.

427 Safety Code Handbook. Fire Equipment Manufacturers' Association offers Handbook of Safety Codes outlining procedures for maintaining, protecting, recharging, inspecting fire extinguishing equipment used throughout the chemical industry.

Chempump minimizes downtime...

pumping bulk nitric acid from delivery truck to customer's storage tank

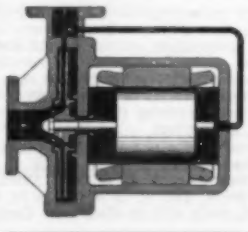
The *Chempump* mounted on this truck can't possibly leak.

For Pressure Vessel Service, Detroit, this simple fact means a considerable saving in truck downtime and maintenance in the delivery of 63% nitric acid to electroplating plants.

The conventional pump formerly used on this truck persistently leaked acid through its stuffing box. The company faced expensive repair or replacement of the acid-corroded truck bed. Pump maintenance was a continual, bothersome expense. Truck downtime was becoming a serious and costly problem.

Now, with a *Chempump* on the job, leakage is eliminated and maintenance is limited to a simple monthly inspection of pump bearings. No external lubrication is needed—bearings are constantly lubricated by the pumped fluid itself.

In any chemical handling application, *Chempump* offers many major advantages. You'll do well to check them. Write to Chempump Corporation, 1300 East Mermaid Lane, Philadelphia 18, Pa. Engineering representatives in over 30 principal cities in the United States and Canada.



Chempump combines pump and motor in a single leakproof unit. No shaft sealing device required.

U.L. approved. Available in a wide choice of materials and head-capacity ranges for handling fluids at temperatures to 1000 F. and pressures to 5000 psi.

Chempump

First in the field...process proved

CEP's DATA SERVICE

Equipment

from page 94

pages) from Barber-Colman Co. describes electric thermostats, pressure controls, humidistats, motor-operated valves, temperature regulators, control centers, accessories. Operation and application data.

308 Controls, level, pneumatic-electronic. Technical bulletin from Robertshaw-Fulton Controls Co. describes new control device said to detect and control changes in liquid level with exceptional precision.

309 Controls, liquid-level. New catalog from B/W Controller Corp. describes liquid-level relays, electrodes, signals, alarms, and alternators. Charts and diagrams of typical applications.

310 Conveyors, pneumatic. Eight-page technical bulletin on practical pneumatic conveyor design offered by Sprout-Waldron & Co.

311 Crucibles, metal melting. Physical and chemical characteristics, uses of crucibles in fused alumina, oxide-bonded silicon carbide, nitride-bonded silicon carbide, fused magnesia, fused stabilized zirconia, thoria, and urania. Catalog from Norton Co.

312 Data Processing System. Bulletin 3017 from Beckman Instruments, Systems Div. gives detailed information on operation, construction, and features of the 210 System.

314 Desiccator, plastic. Has advantages of lightness and extreme resistance to implosion while under vacuum. Data sheet from Ace Glass, Inc.

315 Dissolver, high-speed. For high-speed mixing of batches of from 50 to 200 gallons. Applications in dispersion, dissolving, emulsifying, and deagglomerating in processing solid-liquid, liquid-liquid, or gas-liquid materials up to 50,000 centipoises. Technical data from Cowles Dissolver Co.

316 Drives, agitator. New bulletin from U.S. Electrical Motors describes line of vertical "Syncrogear" motors for industrial agitator applications.

317 Dryers, spray. Brochure from Nichols Engineering & Research describes portable, utility, pilot, and industrial spray dryers. Also outlines research and custom drying facilities offered.

318 Elevators, bulk material, vertical-screw type. Catalog from Southwestern Supply and Machine Works gives details of the Rotor Lift, lists sizes and types, shows construction details and specifications.

322 Equipment, process. Catalog from B. F. Gump gives details of feeders, mixers, sifters, weighers, roller mills, vibrating packers, hammermills, elevators. Illustrations, specifications, engineering data, installation drawings.

323 Equipment, processing. Twenty-four page bulletin from Blaw-Knox, Buflovak Equipment Division, gives specifications, design data for evaporators and concentrators, dryers, flakers, autoclaves, mixers, kettles, special processing equipment.

324 Equipment, processing. Bulletin 200 from Sprout, Waldron and Co. covers equipment for size reduction, classification, mixing and blending, materials handling, pelleting and densifying, pulp refining, and digesting.

325 Fans, all-plastic. Glass-reinforced plastic fans for ventilation of corrosive chemical fumes. Available in capacities to 35,000 cu.ft./min. Data from Heil Process Equipment Co.

326 Fans, heavy-duty. In ratings from 10,000 to 500,000 cu. ft./min., pressures to 70 in. of water, temperatures from 20 to 850°F. Data from Westinghouse Sturtevant Division.

327 Fans, industrial. Construction features, applications, fan arrangements, selection data in 16-page booklet from Day Co. Also temperature and altitude selection data, capacity tables, dimensions, special arrangements.

328 Feeders, weigh. Syntron Co. offers catalog with complete descriptions, data, and specifications on nine gravimetric feeders, automatic batch weigh plants, and bag weigh machines.

329 Filters, oil. Hilliard Corp. offers bulletin with specifications, selection data, detailed construction drawings.

330 Filters, pre-. Bulletin from Anders Lykens Corp. describes the Anders Prefilter used for eliminating entrained liquids and hydrocarbons from gas prior to dehydration. Table of pressures and capacities for standard units.

331 Filters, rotary-drum. New 24-page bulletin from Dorr-Oliver describes designs of five principal types of rotary-drum units and their component parts. Tables of sizes and capacities of each design.

332 Fittings, titanium, forged. Brochure from Harvey Aluminum discusses applications, advantages, gives other technical data.

333 Fittings, UPVC. Complete line of injection-molded unplasticized polyvinyl chloride fitting and flanges is available for large-size (six-inch) piping. Details from Tube Turns Plastics, Inc.

334 Generator, liquid nitrogen. New generator system provides complete nitrogen liquefying facility. Produces up to 95 liters/day of 99.5% pure liquid nitrogen. Details from Arthur D. Little, Inc.

337 Indicator, level, by gamma radiation. Bulletin 558 from Instruments, Inc. gives technical details of their "Radionic" level indicator for determination of liquid or solid level inside a closed vessel. Price list included.

338 Joints, ball. Folder from Barco Mfg. Co. describes application of ball joints to piping expansion or contraction problems.

339 Manipulator, mechanical - arm. Bulletin from General Mills, Mechanical Div., describes remote handling and manipulation systems, lists travel ranges, load capacities, operational speeds. Engineering drawings.

340 Meters, fluid. New technical bulletin from Builders-Providence, Inc. describes methods for selecting standard throats and capacities for Dall flow tubes, Venturi tubes, and Venturi nozzles.

341 Mills, hammer. Technical data from Munson Mill Machinery Co. on its line of hammer mills, said to have about 50% more screen area than conventionally-designed mills.

342 Mixers, batch, tilting. Dimensions and specifications of complete line of tilting batch mixers in bulletin from Gruendler Crusher & Pulverizer Co.

343 Mixers, side-entering. Bulletin from Jensen Engineering Co. describes construction features, gives dimension tables, methods of installation for full line of side-entering mixers.

344 Motors, electric, vertical, all-weather. In ratings from 250 to 2,000 hp. in both hollow shaft and solid shaft construction. Bulletin 2600 from Louis Allis Co.

345 Mufflers, gas and air exhausts. Technical bulletins from Pulsation Controls Corp. describe the Everett Blowdown Mute, designed to eliminate noise from relief valves, pump or turbine exhausts, gas blowdowns, air and steam vents.

346 Pipe, cast iron. Bulletin from Attalla Pipe & Foundry Co. gives sizes, dimensions, approximate weights of "Ni-Resist," high-nickel cast iron alloy pipe, fittings, couplings, and nipples.

347 Pipe, plastic-lined steel. Steel pipe, lined with UPVC, can handle line fluids to 190°F. and pressures to 500 lb./sq. in. Bulletin from Swepco Tube Corp.

348 Pipe, saran-lined. Standard 8-inch saran-lined pipe, for corrosive liquids and gases, is now available from Dow Chemical Co. Technical Data.

349 Pipe, titanium. Bulletin from Carpenter Steel Co., Alloy Tube Div., gives physical and mechanical properties, fabrication characteristics, corrosion resistance of titanium tubing and pipe.

continued on page 98

DEVELOPMENTS OF THE MONTH

SELF-EXTINGUISHING PLASTIC INSULATION

(Circle 430 on Data Post Card)

A completely self-extinguishing, foamed plastic insulation has been developed by Armstrong Cork Co. for low temperature equipment. The material contains a self-extinguishing ingredient which is "locked" into the polystyrene early in the manufacturing process to assure uniform distribution without lessening the over-all thermal efficiency of the product.

Called Armalite, the new material is made in standard sizes ranging from 3 to 15 ft. in length, and from 12 to 36 in. in width. Standard thicknesses are 1, 1½, 2, 3, 4, and 6 in. For further data, circle 430 on Data Post Card.

VANTON *notes on fluid handling*

PUMPS · PIPE · FITTINGS · VALVES

Is Your Fluid Handling Problem Here?

If so, Vanton pumps have been handling it for years with eminent success.

PROBLEM LIQUID	RECOMMENDED MATERIALS* (Body Block & Flex-i-liner)
Acetic Acid	Buna N & Hypalon
Aluminum Chloride	Polyeth. & Nat. Rubber
Ammonia	Polyeth. & Neoprene
Chromic Acid	Polyeth. & Hypalon
Developer Solution	Polyeth. & Neoprene
Distilled Water	Polyeth. & Buna N
Ferric Chloride	Polyeth. & Nat. Rubber
Hydrochloric Acid	Polyeth. & Hypalon
Hydrofluoric Acid	Polyeth. & Hypalon
Hydrogen Peroxide	Teflon & Hypalon
Lime Slurry	Buna N & Neoprene
Methanol	Bakelite & Neoprene
Nitric Acid	Teflon & Kel-F
Phosphoric Acid	PVC & Neoprene
Pickling Bath (H_2SO_4-HNO_3, HNO_3-HF)	Polyeth. & Hypalon
Plating Solutions (Cu, Ni, Ag, Zn)	Polyeth. & Neoprene
(Chrome)	Polyeth. & Hypalon
Sodium Chloride	Polyeth. & Nat. Rubber
Sodium Hydroxide	Polyeth. & Neoprene
Sodium Hypochlorite	Polyeth. & Hypalon
Sulfuric Acid	Polyeth. & Hypalon
Tile Glaze Slurry	Buna N & Nat. Rubber
Titanium Tetrachl.	Teflon & Kel-F
Zinc Chloride	Polyeth. & Hypalon

* In many cases alternative materials of construction are suitable. For complete chemical resistance data, and further information, circle #902.

Vanton Pump & Equipment Corp.
Hillside, N. J.

Please send booklet circled: **901** **902**

*My problem liquid is*_____

NAME_____

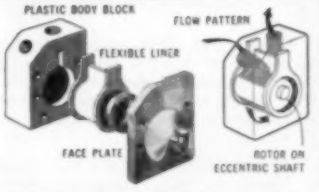
TITLE_____

FIRM_____

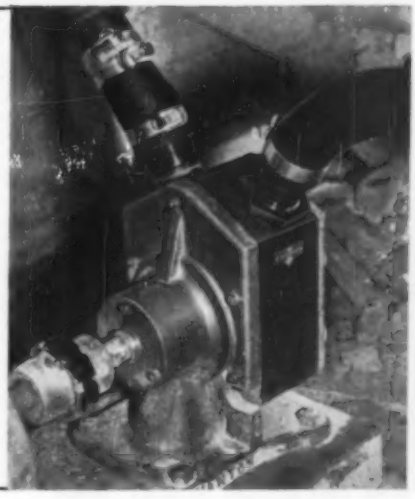
ADDRESS_____

_____

Problem of Pumping Abrasive Cement Additive Solved by Plastic Sealless Pump



HOW VANTON PUMP WORKS Success of the Vanton pump in eliminating leakage and abrasion can be traced to the unique pump design, which eliminates all shaft seals and stuffing boxes. Flanges on the flex-i-liner straddle the pump housing and are pressed to its sides by bolted face plates, forming a separated fluid chamber between the inside of the body block and the outside of the flex-i-liner. Pumping is accomplished by a rotor mounted on an eccentric shaft, rotating inside the liner, creating a progressive squeegee action on the fluid trapped between the liner and the body block. The resilient synthetic liner absorbs any abrasive potential of the material being conveyed, so that slurries which would ruin rigid pump parts pass through the Vanton pump with no scoring action at all.



Diatomaceous earth can be highly abrasive in slurry form, and ruinous to any conventional pump called upon to handle it. That was the problem faced by H. S. Mensing Co., of Finderne, N. J., manufacturers of cement for building and road construction. They had found that a diatomaceous earth additive blended with the cement keeps the mix aerated longer and produces a stronger, harder, smoother set.

Attempts to produce large quantities of the improved product, however, were hampered by unexpected handling problems. The 63% diatomaceous earth slurry, which tended to settle rapidly, caused conventional pumps to malfunction and require constant dismantling and maintenance. Repair and replacement of impellers and scored pump shafts was excessive, with constant leakage. Various conventional-design pumps were tried out, but all proved unable to operate for more than short periods of time without excessive maintenance, parts replacement, and costly production interruptions.

The installation of a Vanton plastic sealless pump, Mensing reports, solved all these problems for good. Settling is no longer a problem, and the soft flex-i-liner absorbs abrasive action of the slurry. In over 2 years of daily operation since installation, the Vanton pump is still going strong, 6 days per week. In these months of continual operation, the only maintenance required has been the replacement of one inexpensive flex-i-liner.

Vanton pumps are available in a wide range of plastic and synthetic materials, including DuPont Teflon, high-temperature polyethylene, PVC, and bakelite. Capacities range from ⅓ to 40 GPM. For more information, circle #901.

VANTON PUMP
and Equipment Corp. • Hillside, N. J.
DIVISION OF COOPER ALLOY CORP.

CEP's Data Service—

Equipment

350 Pulverizers. Bulletin from Sturtevant Mill Co. describes the Micronizer, a fluid energy mill for simultaneous grinding and classification to ultra-fine particle size.

351 Pumps, centrifugal, alloy. Specially designed for filtrate and transfer applications in the chemical process industry. Technical data from Dorr-Oliver.

352 Pumps, gas, rotary-positive. Bulletin from Roots-Connersville Blower gives complete details of Type XA rotary positive gas pumps, available in 18 sizes.

353 Purifiers, dry. Centrifix Corp. Valuable materials entrained in hot gas or air streams removed with no heat loss. Full technical details.

356 Regulators, flow-rate. For liquids and light slurries. Type F regulators, made by W. A. Kates Co., operate with minimum pressure difference of less than 10 lb./sq. in. Technical data.

357 Regulators, valve. Bulletin 1098 from Rockwell Mfg. Co. describes applications and operation of pneumatically-controlled, cylinder-operated, lubricated plug valve regulators.

358 Rotameters. Specification sheet from Fischer & Porter Co. describes new indicating meter featuring "snap-in" tube construction, that eliminates need for operating and maintenance adjustments, has no packing or stuffing boxes.

359—Scales, batching, constant-feed. Use of electronic closed circuit provides high dynamic accuracy. Thayer Scale Corp. Detailed technical information.

360 Separators, nozzle-type. Tables of rated capacities, fields of application, economic data contained in 8-page bulletin from Centrico, Inc.

361 Separators, vibrating-screen. Bulletin S-581 from Southwestern Engineering gives operating, application, and specification data.

362 Spectrophotometer, infrared. Perkin-Elmer Corp. offers 24-page brochure on the Infracord double-beam infrared spectrophotometer.

363 Steam Generators, forced-recirculation. Bulletin from Clayton Mfg. Co. describes single unit, centralized or decentralized multiple unit installations.

364 Steam Traps. V. D. Anderson Co. offers 40-page engineering manual on sizing, specifying, selection, and buying of steam traps and other fluid specialties.

365 Submerged Combustion Equipment. Bulletins from Ozark-Mahoning Co. describe use of submerged combustion equipment for evaporation and/or heating, waste disposal problems, etc.

366 Tanks, plastic. Catalog sheet from American Agile Corp. describes line of standard tanks in polythylene and polypropylene. Specifications, design features, application data for each type tank.

370 Thermocouple Assemblies. Bulletin 5804 from Conax Corp. describes complete line of thermocouple assemblies and pressure sealing glands.

371 Thermometers, dial, bi-metallic. Catalog from Moeller Instrument Co. gives specifications, construction details, prices.

372 Thermometers, resistance. New 36-page catalog from Leeds & Northrup gives complete information on their Thermohm detectors for temperatures up to 1,000°F. Tabular listing of specifications by application and design.

373 Transistors. New high-temperature transistors function continuously at 1,200°F. Fully described in catalog from Fenwal Electronics.

381 Valves, butterfly. Loose-leaf catalog from S. Morgan Smith Co. gives details of flanged and wafer valves, complete information on modifications of standard valves, and on operators and positioners.

382 Valves, butterfly, positive-seal. New line of solid aluminum bar stock butterfly valves in ¼, ⅜, ½, ¾ and 1-in. sizes. Bulletin from Keystone Valve Corp.

383 Valves, check, rubber-lined. Brochure 957 from Allen-Sherman-Hoff Pump Co. shows specifications, engineering details of its line of "Flex-Check" valves.

384 Valves, control, air-operated. No stem packing or stuffing box. Bulletin with full details from Uniflow Valve Corp.

385 Valves, corrosion-resistant. Catalog from W. G. Rovang & Associates describes stock, wedge gate, check, throttle, and digester cap valves in special alloys and plastics.

386 Valves, flanged. New series of flanged globe and angle valves, said to be ideal for ammonia service is offered by Bastian-Blessing Co. Technical data.

387 Valves, gate, multiple-seal. A new leak-proof valve for aromatics, hydrocarbons, and LPG. Full details and specifications from Vernon Tool Co.

388 Valves, glass, Y-type. Recommended for all metallic salts, various crystalline slurries, all acids except hydrofluoric and hot concentrated phosphoric acids. Available in 2 and 1½ inch sizes. Data from Corning Glass Works.

389 Valves, high pressure. New union bonnet cylinder valve for pressures up to 3,000 lb./sq. in. Complete technical details. Hoke, Inc.

390 Valves, magnetic and motorized. Catalog V-58 from Mercoid Corp. describes complete line for air, water, gas, steam, refrigerants.

391 Valves, needle, high-pressure. Maximum working pressure 10,000 lb./sq. in. at 70°F. Maximum operating temperature 750°F. Technical data from Kerotest Mfg. Co.

392 Valves, regulating. Bulletin 1053 from Copes-Vulcan Div., Blaw-Knox, gives specifications on sizes, pressures, materials of construction.

393 Valves, regulator. Sizing charts for OPW-Jordan sliding gate and plate regulator valves. Jordan Corp.

394 Valves, replaceable-seat. Keystone Valve Corp, offers Comparative Guide of chemical resistant characteristics of various metals and resilient seat materials.

395 Valves, steel. Comprehensive 92-page catalog from Edward Valves, Inc. covers complete line of cast steel and forged steel valves for the power, petroleum and chemical industries. Condensed rating tables on all listings.

396 Valves, throttling. Basic 2 in. valve body may be combined with 13 interchangeable port-flanges. Data from Greer Hydraulics, Inc.

397 Waste Treatment Systems. Application engineering data sheet from Milton Roy Co. describes continuous cyanide and chrome wastes treatment systems.

Materials

419 Sodium Benzoate, Benzoic Acid. Physical properties, available forms, applications of sodium benzoate and benzoic acid described in new bulletin from Hooker Chemical Corp.

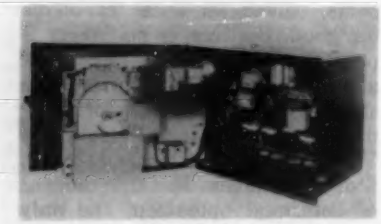
420 Sodium Hydride, dispersions in oil. Metal Hydrides, Inc. offers a manual of technical data covering properties, reactions, handling, and safety.

421 Solvents. Guide provides complete specifications on aliphatic naphthas, paraffinic hydrocarbons, aromatic hydrocarbons. Solvent selection data. American Mineral Spirits Co.

422 Steel, stainless. Allegheny Ludlum Corp. offers revised 40-page booklet on the use of stainless steel in the chemical industry.

423 Zirconium Oxide and Chloride. High-purity hafnium-free zirconium oxide and tetrachloride are now available in tonnage quantities from Columbia-National Corp. Technical data.

DEVELOPMENTS OF THE MONTH



CHROMATOGRAPH INTEGRATOR

(Circle 431 on Data Post Card)

Newly-developed instrument automatically records on a strip chart up to 12,000 counts per minute per inch of chart. Features a new miniature integrator, accurate to 0.1% of full scale. Mechanism is run immersed in oil for long life.

Kits are now available from Disc Instrument Co. for Brown "Electronik," including the 1 second, and for Briston "Dynamaster" recorders. Kits for other recorders can be obtained on special order.

For a descriptive brochure and a new Beckman Instruments, Inc. bulletin on peak area measurement techniques, circle 431 on Data Post Card.

SHEDDING NEW LIGHT ON PRECOAT FILTRATION PROBLEMS

It is generally known in engineering circles that the theory of filtration has not yet reached the point where flow rates and the degree of clarification can be predicted accurately. Plants using supposedly identical systems to filter raw sugar liquors, antibiotic fermentation brews, varnishes, or whatever, will experience extremely wide divergences in filtration rates.

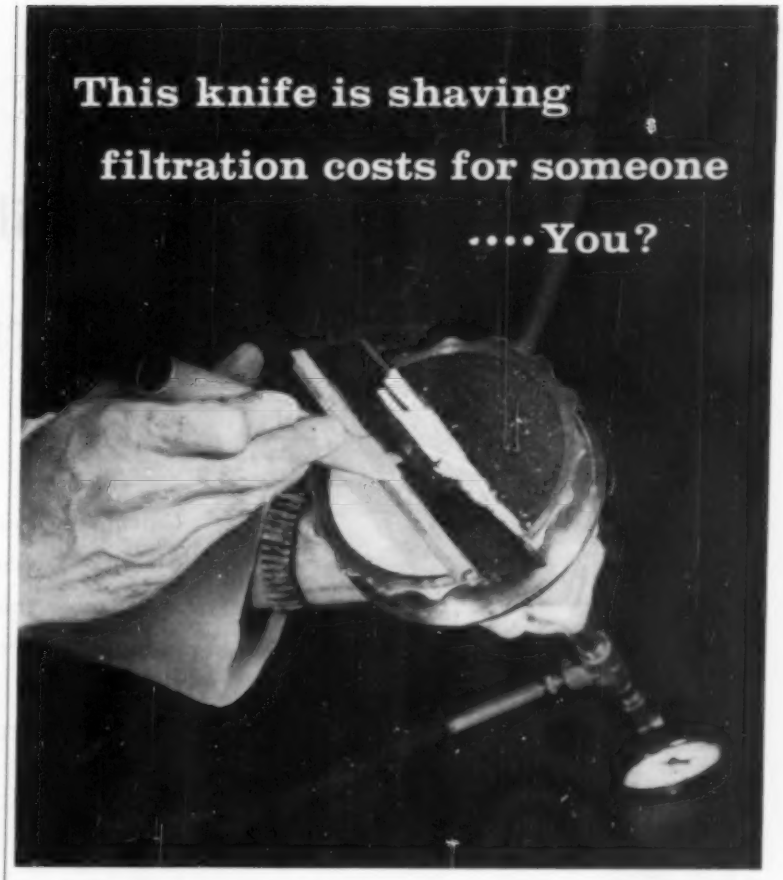
Accurate determinations of filtration costs and the sizing of equipment can thus be made only by actual filtration tests. While the well-known Dicalite Bomb Filter has provided a means of investigating batch pressure filtration operations, no comparable test device has been available to industries using or planning to use rotary vacuum (or pressure) precoat filters. Consequently, the necessity for time consuming and expensive pilot plant testing of precoat filter systems has seriously impeded the introduction of this labor-saving equipment where it offered potential cost reductions.

Now, after several years of laboratory development and field testing, we are proud to announce that Dicalite has developed a precise and accurate Precoat Test Leaf, available for general use, which allows study of all the process variables of precoat filtration in the laboratory. Drum speed, grade of filteraid, amount of filteraid and depth of cut can all be checked out rapidly and easily. The results obtained, and predictions based thereon, correlate closely with actual plant production results.

Our own tests and field experience indicate that many precoat filter operators can cut their filteraid costs by at least 20% – and in some cases savings up to 50% are possible even in "blue chip" concerns. These savings result either from a change in the grade of filteraid employed, or from adjustments in one or more operating factors which could not be accurately checked in large-scale production units.

If you have a potential precoat filtration application, or if you presently operate a precoat filter and want a quick test of the possibility of cutting operating costs, we suggest that you get in touch with your Dicalite sales engineer. We are not in the business of selling test units, but we will be glad to run tests for you, or to assist you in obtaining a Dicalite Precoat Test Leaf for your own use.

P. W. Leppla, Technical Director



Here, a problem in rotary vacuum precoat filtration is being worked out with a new laboratory-scale testing device. And, when the tests are completed, *all* the answers for optimum filtration will be there... maximum through-put at desired clarity, with the most economical dosage and grade of filteraid. This new test leaf, a product of Dicalite research, is the only such device which provides the all-important feature of precise and accurate shave-off control. Hence, it can determine, in the laboratory, the effects of all the process variables – with only a few gallons of process liquor – in just a few hours – with an accuracy never before possible even in pilot plant tests.

Tests made with this Dicalite Precoat Test Leaf have already effected filtration economies for many Dicalite customers, coast to coast. If you would like further information on this device, we will be glad to send you an illustrated reprint of a paper read before an A.I.Ch.E. meeting and later published in a leading chemical journal. Just write us, or ask your local Dicalite sales engineer.

Dependable GLC GREAT LAKES Dicalite DIATOMACEOUS MATERIALS

Among the DIATOMS shown here:

SYNEDRA
NAVICULA
CYMBELLA
SURIRELLA
COSCINODISCUS
ACTINOPTYCHUS
EPITHEMIA
EUNOTIA

Dicalite Department, Great Lakes Carbon Corporation
612 South Flower Street, Los Angeles 17, California

Tyler Davidson fountain at night

Versatile Cincinnati

Cincinnati, host to the A.I.Ch.E. Annual Meeting December 7-10, is justly proud of its versatile traditions and facilities. A major chemical center, the city on the banks of the Ohio is also a center of culture and entertainment for the entire Ohio Valley.

One of the nuclei from which sprang the now gigantic American chemical industry, Cincinnati continues to be a major chemical manufacturing center. It was in 1837 that William Procter, soap maker, and James Gamble, candle maker, joined forces under the firm name of Procter & Gamble. Today, Procter & Gamble's Cincinnati plant occupies some 200 acres, employs about 6,000 people. The firm is the world's largest manufacturer of soap and allied products, has annual sales of about $1 billion. Another early starter was Emery Industries, founded in 1840 by Thomas Emery, who manufactured lard, oil and tallow candles. Emery's main products today are fatty acids and their derivatives, textile oils, monomeric ester plasticizers, emulsifiers, and fat-splitting reagents. Procter & Gamble and Emery are not alone in Cincinnati—here are located more than 175 chemical manufacturing plants, not to mention firms such as Vulcan-Cincinnati, Chemical & Industrial, and others which specialize in design and construction of chemical processing plants and equipment. Since the early days of the whiskey industry, Cincinnati has been a center for copper (now alloy, etc.) process equipment fabrication. Davison, Monsanto, Virginia-Carolina — these are only a few of the major producers in the Cincinnati metropolitan area. In Fernald, a suburb, the AEC operates a large uranium production plant.

"Overnight from Everywhere." Cincinnati's central location will make it possible for chemical engineers from anywhere in the United States to attend the coming Annual Meeting, December 7-10, Netherland Plaza Hotel. In fact, transportation is the very lifeblood of the city. It is served by seven railroads, five airlines, and by a vast network of water transport on the Ohio. Its riverfront, extending for some ten miles, can be considered one of the great ports of the world. Here are great oil and freight terminals, and depots from which the entire Northwest is supplied with coal. (An anachronistic note—from Cincinnati leave the only packet boats still plying the Ohio—shades of Mark Twain.)

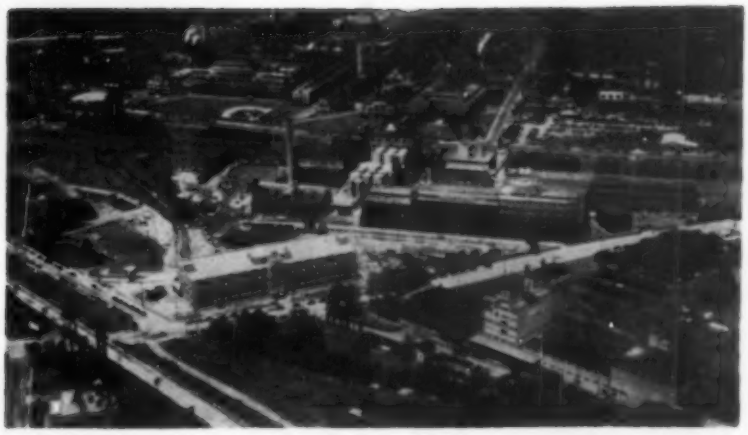
Visitors to the A.I.Ch.E. December Annual Meeting will have a chance to inspect many of these plants at first hand. Plant trips already scheduled include Interchemical Corp., Procter & Gamble, Armco. A dozen more are under consideration, will be listed in *CEP* in October.

The old and the new

Tradition and innovation will be mixed in the extra-curricular events at Cincinnati. Traditional will be the Get-Acquainted Party on Sunday, and the President's Luncheon on Monday. Something distinctly new will be the Unit Operations Luncheon on Tuesday. At each table will be a nationally-known expert in some particular phase of Unit Operations. Guests will have an opportunity to meet and to exchange views with the expert of their choice. Here is a chance to talk Absorption with T. H. Chilton, Evaporation with Arthur Rose or Aaron Teller, Extraction with Ed Scheibel, Filtration with William Licht, Fluid Flow with Bob Pigford, Fluidization with Max Leva or Walter Lobo, Heat Transfer with Emerson Lyons, to mention just a few.

The Cincinnati Art Museum, one of the centers of culture in the Ohio Valley.

Procter & Gamble plant, Cincinnati

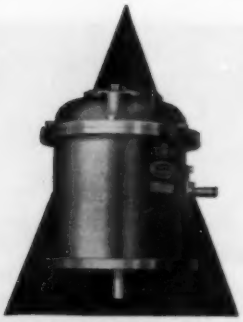


To turn to the formal program. Good Housekeeping will be the theme of the session on Pollution Control by In-Plant Measures (C. Fred Gurnham). Up-to-date recovery methods, sometimes combined with process changes, can be a paying business for chemical manufacturers, particularly in areas where pollution control is a necessity. Case histories will be adduced from the pulp and paper industry and from petroleum refining. . . . Specially for the benefit of design engineers will be the symposium on A.I.Ch.E. Research on Bubble Cap Tray Efficiency (W. C. Schreiner). For the first time, there will be made public the results of years of concentrated work in a field vital to a wide range of chemical processing operations. This is a "must!" . . . Amazing discoveries in agitation flow patterns, the phenomena of high explosives, and nucleate boiling bubble growth will be revealed in the symposium on High-Speed Photography in Chemical Engineering (J. W. Westwater). Its all done by high-speed movies. . . . Kinetics and Rate Processes (H. E. Hoelscher) can be counted on for fundamental contributions to the area. . . . An improved solution of problems in the design of cooler-condensers by use of a large digital computer features the session on The Application of Computers to Heat and Mass Transfer (J. M. Smith). . . . Two sessions will be devoted to the topical matter of reprocessing nuclear fuels. On the more technical side will be the symposium on Reprocessing of Fluid Reactor Fuels (G. E. Dwyer) which will be highlighted by a discussion of the production and use of molten fluorides as reactor fuels. Processing of Irradiated Fuels—a Challenge for the Future (J. L. Schwenneses) will work the other side of the street. It will be a commercially oriented panel discussion—eight short talks by members of leading companies in the field, plus two AEC technologists. Companies represented will include Vitro, Blaw-Knox, General Electric, Phillips Petroleum, Koppers. . . . Free radical research—one of tomorrow's frontiers—underlines the importance of the session on Low Temperature Processing (C. McKinley). Also on the agenda will be production of high-purity CO, and liquid oxygen purification. . . . Scale-up from Pilot Plant to Plant (D. B. Coghlan) will feature the use of analog computers in pilot plant design, and actual design data on scale-up of mixer-settlers. . . . For those involved in—or headed for—management functions, the symposium

continued on page 102

Committee. Seated (l. to r.) St. John, Wiehe, Katzen, Barrows. Standing (l. to r.) Romell, Head, Pettengill, Reiss, Brown, Steioff. Absent were Thomson, Peddicord. Gilbert, Baechle, and Chavent.

Ladies Committee. Seated (l. to r.) Mrs. St. John, Head, Barrows, Diebold, and Carlson. Standing (l. to r.) Mrs. Romell, Brown, Swetland, Hersman, Katzen, Wiehe, Reiss, and Moon, Jr.



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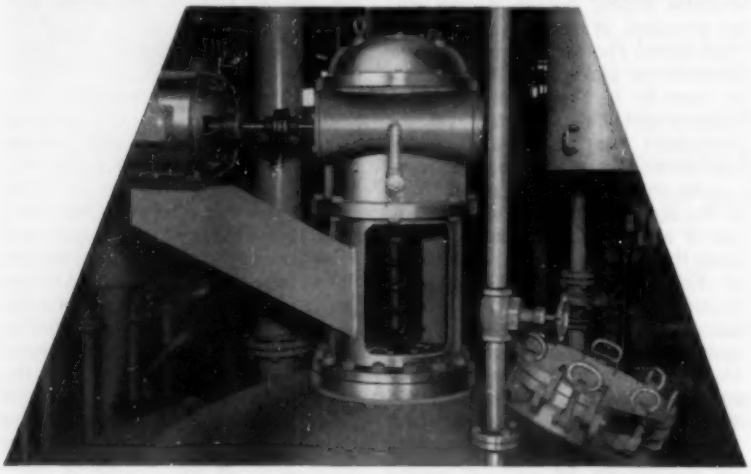

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Model T units, featuring helical gear trains and worm gears in combination, offer ratios from 6.25:1 to 100:1 in numerous "process-rated" models designed for dependable, economical operation. Ask Nettco agitation engineers for recommendations. Request Bulletin 551 and data sheet from **New England Tank & Tower Company, 92 Tileston Street, Everett 49, Mass.**

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- ☐ Pipeline-Flomix®—Bulletin 531
- ☐ Side Entering—Bulletin 532

Cincinnati

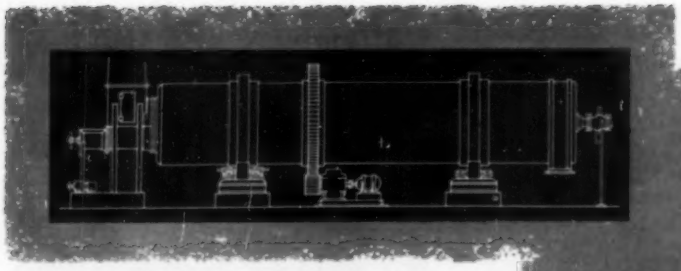
from page 101

on Guideposts in Long Range Planning (R. W. Schram) will be of extra special interest. Discussions will revolve around the "momentum factor," and other modern techniques of decision-making. . . . Fundamental theory, engineering research, heat and mass transfer, plus data on the design of spray nozzles, all this will be part of the session on Spray Mechanisms (J. F. Tourtelotte). . . . Practical data on air-cooling equipment, and comparison of its efficiency and cost with those of water cooling methods is the theme of the symposium on Air-Cooled Heat Exchangers (W. W. Akers). . . . Another panel discussion —Education in Process Control (T. J. Williams). Participants will be chiefly leading educators, subject material will be the control of undergraduate and graduate chemical engineering education to turn out competent process control engineers. . . . The role of A.I.Ch.E. in the academic area will be discussed by a panel in Education and Accreditation (C. C. Monrad). . . . Highlight of the General Papers session (W. Licht, Jr.) will be an ac-

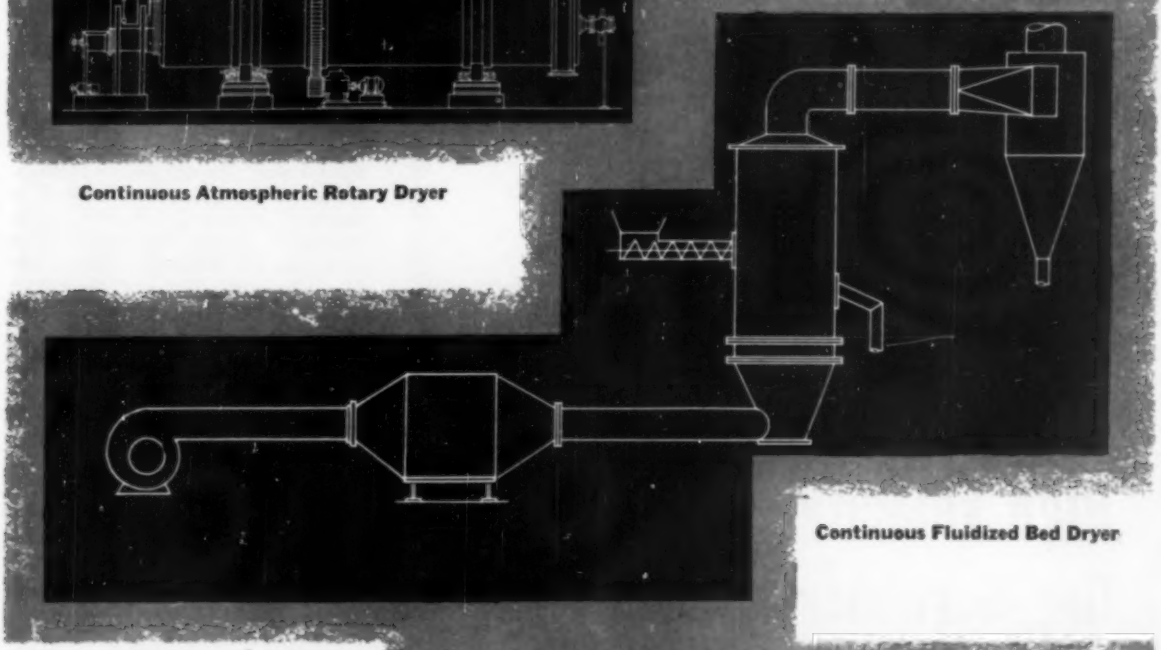
continued on page 104

Technical Program

Genl. Mtg. Chmn.: T. B. Wiehe, Schenley International. Tech. Prog. Chmn.: A. C. Brown, Emery Industries, Inc. June & Long Sts., Ivorydale, Ohio. **Pollution Control by In-Plant Measures** (2 sessions)—C. Fred Gurham, Dept. of Chem. Eng., Michigan State U., East Lansing, Michigan. **A.I.Ch.E. Research on Bubble Cap Tray Efficiency** (2 sessions)—W. C. Schreiner, M. W. Kellogg Co., 711 Third Ave., New York 17, N. Y. **High-Speed Photography in Chemical Engineering**—J. W. Westwater, William Albert Noyes Laboratory, Univ. of Illinois, Urbana, Ill. **Kinetics & Rate Processes**—H. E. Hoelscher, Dept. of Chem. Eng., Johns Hopkins Univ., Baltimore 18, Md. **Reprocessing of Fluid Reactor Fuels**—O. E. Dwyer, Chem. Eng. Div., Brookhaven National Laboratory, Upton, L.I., N. Y. **The Application of Computers to Heat and Mass Transfer Problems**—J. M. Smith, Northwestern Univ., Evanston, Ill. **Low Temperature Processing**—C. McKinley, Air Products, Inc., Allentown, Pa. **Scale-up from Pilot Plant to Plant**—D. B. Coghlan, Foote Research and Development Laboratories, Berwyn, Pa., R. A. Schulze, DuPont Chambers Works, Jackson Labs., Penns Grove, N. J. **Guideposts in Long Range Planning**—R. W. Schramm, Union Carbide, 30 E. 42 St., N.Y.C. **Processing of Irradiated Fuels—A Challenge for the Future** (2 panel sessions) —J. L. Schwennesen, A.E.C., P.O. Box 1221, Idaho Falls, Idaho. **Spray Mechanisms** (2 sessions)—J. F. Tourtellotte, Swenson Evaporator Co., 18505 James Couzens Highway, Detroit, Mich. **Air-Cooled Heat Exchangers**—W. W. Akers, Dept. of Chem. Eng., Rice Institute, Houston, Texas. **Education in Process Control** —T. J. Williams, Monsanto Chem. Co., 1700 S. Second St., St. Louis 4, Mo. General Papers (2 sessions)—W. M. Licht, Jr., University of Cincinnati, Cincinnati, Ohio, and S. C. Hite, University of Kentucky, Louisville, Ky. **Recent Trends in Chemical Engineering Education and Accreditation**—C. C. Monrad, Chem. Eng. Dept., Carnegie Inst. Tech., Pittsburgh 13, Pa.



Continuous Atmospheric Rotary Dryer



Continuous Fluidized Bed Dryer

Continuous Solvent Stripper
Continuous Gas Solids Reactor
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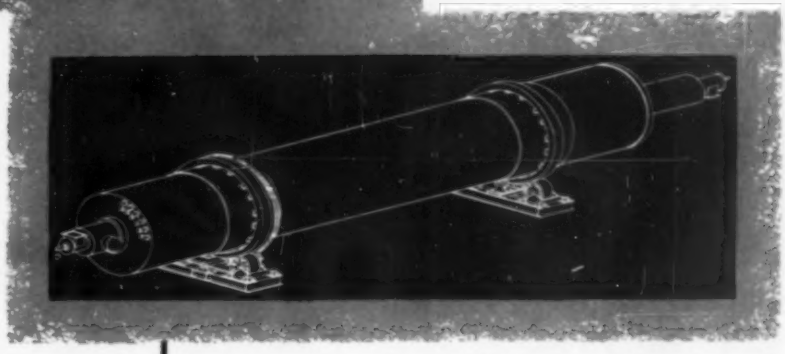

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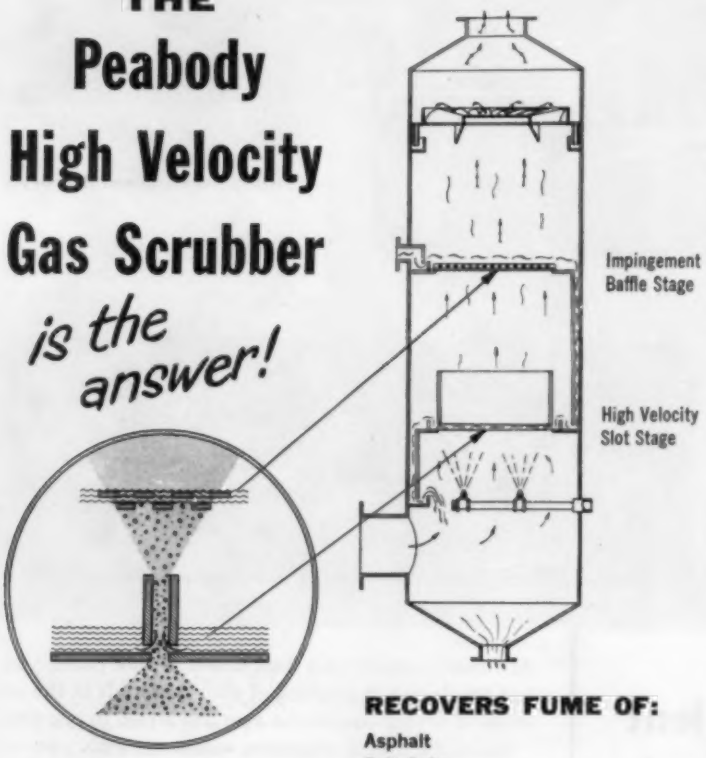

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Cincinnati

from page 102

count of recent Russian work in distillation and related subjects.

On the lighter side

Like Rome, Cincinnati was originally founded on seven hills. Like Rome's, its metropolitan area has long since spread beyond its early limits. However, the heart of Cincinnati is amazingly compact. Its theatres, its fashionable shops, its transportation terminals, its clubs, are within a few blocks of each other, in a downtown district hemmed in by the steeply-sloping banks of the Ohio River.

The old rip-roaring saloons of Vine Street are gone. Vine Street remains. Today, this longest of Cincinnati's streets is dedicated to good food—and to good drink. Not only on Vine, but everywhere you go in Cincinnati, are to be found some of the finest of America's restaurants. No visitor will want to miss an ancient landmark—Grammer's German restaurant. Does your taste lean more toward French cuisine—La Maisonette, the Gourmet, Pigall's. Italian?—Caproni's, the Isle of Capri. Chinese?—the Canton, the Mandarin. American? — Town and Country.

Like to dance between courses—or between drinks? For you, the Glen Rendezvous, Cat & Fiddle, the Sidewalk Cafe, or across the river at the fabulous Beverly Hills, Kentucky's noted luxury wagering establishment. Top-notch entertainment, too.

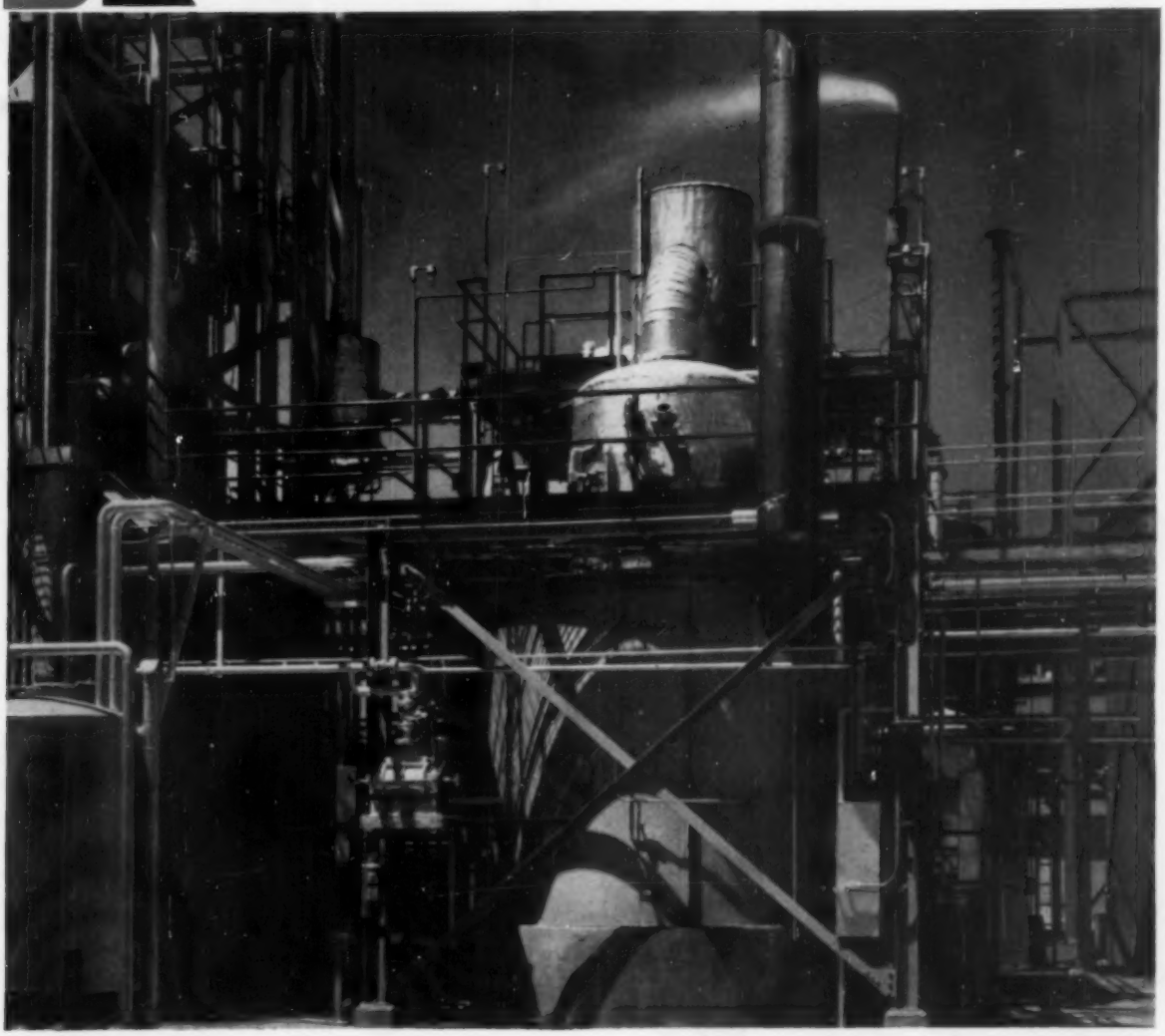
Evening fare in Cincinnati is not, of course, confined to its however admirable "night spots". For lovers of the legitimate theatre, there is the Shubert, where top Broadway hits are the rule. For the musicians, there will be the noted Cincinnati Symphony in Music Hall.

Sports fans will have their innings, too. In particular, they will not want to miss seeing the University of Cincinnati "Bearcats" in action. This is one of the country's top-flight basketball outfits.

German night

To return to the planned entertainment schedule, Monday evening will feature an "Over-the-Rhine Party," with all the German atmosphere and flavor for which Cincinnati is famous. In a Gay Nineties setting, a German band will provide the music for singing and entertainment. A typical German beverage, served in bottomless glasses, will heighten the spirit of the evening. The Annual Awards Banquet on Tuesday evening will end the planned entertainment events.

Blaw-Knox builds for HumKo, ***Division National Dairy Products Corp.,*** **a radiant heated batch fatty acid still. Supplementing a continuous still previously supplied by Blaw-Knox, this new unit increases HumKo's output of fatty acids and improves production efficiency.**



Industry's first radiant furnace cuts fuel costs ... tightens temperature control

New economies for batch fatty acid distillation are introduced with the Blaw-Knox Radiant Furnace. Proven and popular in resin and plastic operations, this unique furnace brings the same design advantages to the fatty acids industry.

The furnace features a light, stainless steel shell surrounded by light weight, high temperature insulating material. About 75 percent of the heat to the batch is supplied by radiation from furnace walls. This speeds heating and provides improved response to temperature control. Low heat retention and effective insulation cut heat losses, account for significant fuel savings. Reduced maintenance is an added bonus.

The radiant furnace is a pace setting product of a continuing process development program. *Experienced initiative* sparks all projects undertaken by Blaw-Knox's complete engineering and construction service.

When planning your next project—a new plant, or modernization, or expansion, contact Blaw-Knox Company, Chemical Plants Division. Headquarters in Pittsburgh. Branch offices in New York, Chicago, Haddon Heights, New Jersey, Birmingham, Washington, D.C., and San Francisco.

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Greater Capacity . . .

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for Solids Dewatering

SHARPLES ADVANCED DESIGN CENTRIFUGES

P-7000 SUPER-D-CANTER — The largest of six sizes of continuous scroll type solids discharge centrifuges for the clarification of crystalline or amorphous solids . . . The P-7000 will handle solids at rates in excess of 12-15 tons/hr. *For operation at pressures to 150 psi.*

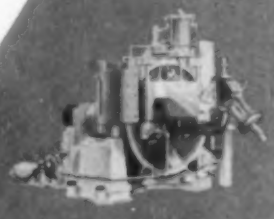
SUPER-D-HYDRATORS — These high efficiency crystal drying centrifuges are available in 3 sizes, the largest of which has a capacity on ammonium sulphate in excess of 20 tons/hr. *For operation at pressures to 150 psi.*

DH-6 NOZLJECTOR — Designed to handle feeds in excess of 500 gallons per minute. This is the largest of 3 sizes of continuous solids discharge nozzle type centrifuges for the clarification and concentration of solids in slurries and sludges. *For operation at pressures to 150 psi.*

Sharples is setting new standards of capacity and all-round performance with the only really new centrifuges being offered today. If a solids dewatering step is necessary in your processing, it will pay you to get the facts from Sharples.

Your inquiry will be given our prompt attention.

P-7000 VERTICAL SUPER-D-CANTER



SUPER-D-HYDRATOR for dewatering crystals

* The bowl (rotor) of a pressurized D-XS NOZLJECTOR—the largest and highest capacity nozzle type centrifuge available to industry.

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LET GRAHAM DO IT

We have developed the Graham Steam Jet Ejector to a degree of perfection that provides industry with an economical and reliable source of vacuum at low first cost.

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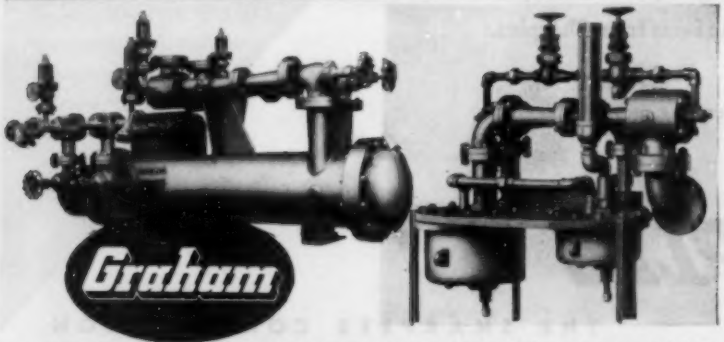

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industrial news

A substantial increase of research and training has been recommended for the Robert A. Taft Sanitary Engineering Center in Cincinnati. A large part of the new funds will go to research on radiation injuries, and on air and water pollution. #

Awards for study in statistics for persons specializing in physical, biological, or social sciences are offered by the Department of Statistics, University of Chicago. Awards range from $3,600 to $5,000, closing date for application is February 16, 1959. Information from Dept. of Statistics, Eckhart Hall, University of Chicago, Chicago 37, Ill. #

European papers given at the recent Montreal meeting of the A.I.Ch.E and C.I.C. have been published in the June, 1958 issue of The Canadian Journal of Chemical Enginering. Copies are available from the Chemical Institute of Canada, 18 Rideau Street, Ottawa, Ont. Cost is $1.00 per copy. #

More than 10 million pounds per year of epoxides and other oxygenated chemicals will be produced in a new Union Carbide Chemicals plant at Institute, West Va. New products of the unit, slated for completion in mid-1959, are Epoxide 201, vinylcyclohexene dioxide, vinylcyclohexene monoxide, dicyclopentadiene deoxide, styrene oxide, allyl epoxystearate, and caprolactone. Special emphasis will be placed on Epoxide 201 (3, 4-epoxy-6-methylcyclohexylmethyl-3, 4-epoxy-6-methylcyclohexanecarboxylate). The material is said to form plastics and coating resins of outstanding color stability and resistance to heat distortion. #

On stream in September will be a new methylamines plant at the Wyandotte, Mich., works of Pennsalt Chemicals. Mono-, di-, and trimethylamine will be produced in the new unit, will go to agricultural chemicals, pharmaceuticals, dyestuffs, rubber accelerators, feed additives, ion exchange resins, spinning solvents for synthetic fibers, photographic chemicals, and detergents. #

Two new industrial gas installations, value more than $2.5 million, have been dedicated in the San Francisco Bay area by the Liquid Carbonic Division of General Dynamics. One plant, at Oakland, will produce oxygen, nitrogen, and argon; the other, at San Carlos, will make hydrogen. #

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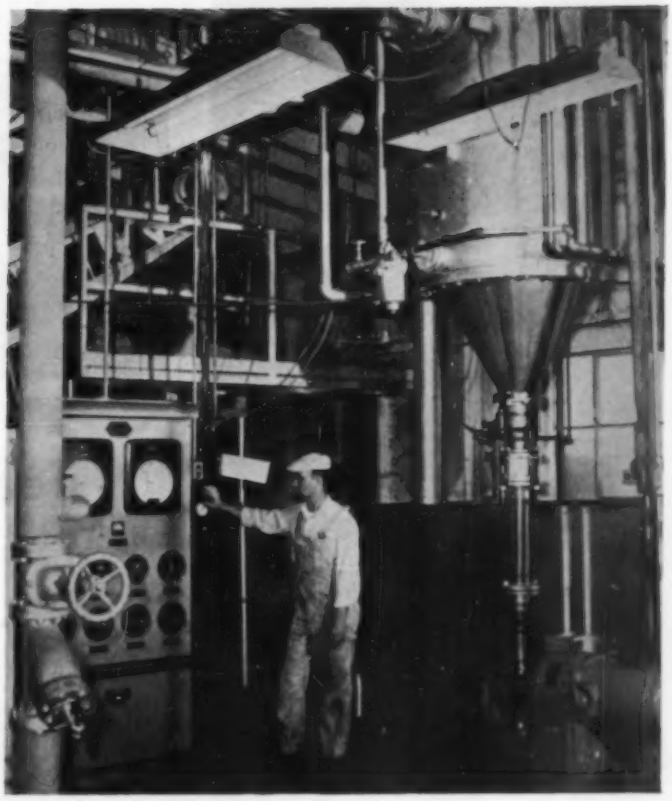

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Rodney Hunt welcomes specific requests for help in solving process problems involving mechanically aided heat and mass transfer, for product testing and for evaluation of processing techniques. Our fully equipped laboratory and pilot plant is staffed by engineers and technicians with wide experience across the entire range of thin-film processing, from one-half micron to atmospheric pressures.

For those who prefer to do their own testing and research, portable laboratory-size Turba-Film and Vacu-Film Processors are available for purchase or rental. With these units, thin-film processing techniques can be properly evaluated. Test results obtained from pilot-size Vacu-Film and Turba-Film Processors can be readily extrapolated to production-size units.

Please address your inquiries to the Process Equipment Division.

The Del Monte label has long meant superior quality in canned and processed foods. In producing Del Monte fruit concentrates, the California Packing Corporation uses a Rodney Hunt Turba-Film Processor to assure desired quality and character—a thick paste with fine flavor and good color.

Operating 24 hours a day during the peak season, this Turba-Film Processor maintains an excellent operating record with a minimum of maintenance. Pears and apricots are processed to a concentration of about 2.5 to 1 at a rate of 5 tons per hour—tomatoes to a concentration of about 3.5 to 1 at 3 tons per hour. And the equipment is readily variable to meet the different heating temperatures and operating pressures required for each product.

The taste and quality of the concentrate is protected from the injurious effects of overheating because of the precisely controlled, short-time exposure of the product in the thermal section. This is one of the most important advantages of the Rodney Hunt Turba-Film Processor—an advantage that has been widely applied throughout the process industries. Whether for chemicals, petroleum residues, pharmaceuticals and other temperature-sensitive products, the Turba-Film Processor will consistently and automatically retain the essential properties and desired qualities of the product being processed.

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SERVING THE PROCESS INDUSTRIES WITH EQUIPMENT AND ENGINEERING

Planning the day's doings at the DuPont ammonia school for professors. Left is A. B. Stiles of DuPont, right is J. H. Koffolt of Ohio State University.

In the compressor room, Belle ammonia plant, DuPont.

Teaching horizons broadened by industry "schools"

Today, many teachers of chemical engineering are finding it possible to get first-hand training in industry through short-course "schools" organized and presented by chemical companies.

"If every company provided this type of program, chemical engineering education would improve 100%." Such was the typical reaction of one of the "professor-students" who participated in a one-day school for chemical engineering teachers held at the Belle, West Va., Du Pont Works.[1]

Subject of the Du Pont school was modern ammonia synthesis (see "Nitrogen Americana", CEP, May, 1958); in attendance were 58 teachers of chemical engineering from 29 different colleges and universities. The success of the program is ascribed by Du Pont to several factors: the initiative of key A.I.Ch.E. members[2] in planning and organizing; the detailed preparatory work of the Du Pont men who acted as "professors"; and the immediate and enthusiastic response of the teachers invited to attend.

Illustrative of the care taken in preparation of the program was the

continued on page 112

[1]The school was one of three which have been sponsored within the last few months by the Chemical Engineering Education Projects Committee of A.I.Ch.E. in collaboration with chemical companies.

[2]Leading organizers were Joseph H. Koffolt, chairman of the Dept. of Chemical Engineering at Ohio State, and R. C. Kintner, chairman of A.I.Ch.E's Special Projects Committee.

Participants in the recent Middle Atlantic area school at Rohm & Haas, Philadelphia.

Around the conference table at Texas City. At right front is "Professor" Jack Horner of American Oil.

Need a packaged process plant?

GIRDLER can supply them
for producing... HYDROGEN
CARBON DIOXIDE
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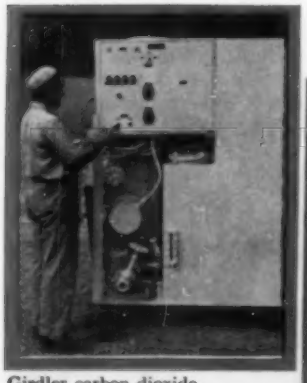
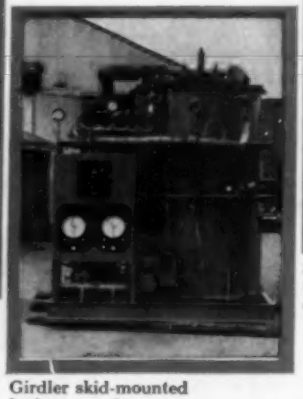
or for purifying NATURAL GAS

Girdler shop-assembled processing units are ideal for: Applications requiring small plant capacity with large plant efficiency . . . locations where construction labor is not available . . . special situations where extreme compactness or mobility is desired . . . stand-by or auxiliary facilities. These packaged plants are available for various raw materials, fuels and treating conditions.

For full particulars, write our nearest office stating your requirements.



Girdler carbon dioxide removal unit.



Girdler skid-mounted hydrogen reformer.

Skid-mounted Girbotol unit for purification of natural gas.

One-eighth scale model of Girdler portable hydrogen plant.

DO YOU HAVE A LIQUID DRYING PROBLEM?

You can now attain water levels below 10 ppm and sometimes below 1 ppm by using Molecular Sieve driers. This degree of dryness would be difficult or impossible with paper presses, distillation towers or chemical desiccants.

Molecular Sieve drying systems are available in any size with either single or multiple beds. Operation can be continuous or intermittant and variation of flow rates or composition of the stream does not affect product purity. Even at low inlet water levels, Molecular Sieve systems maintain a high water capacity. *And*, important in so many areas, Molecular Sieves have high water capacity even at elevated temperatures.

Many plants are now taking advantage of this highly efficient method of drying liquid systems. Here are some examples of liquids which are now being dried commercially with LINDE Molecular Sieves—

Acrylonitrile	n-Hexane
Benzene	Phenol
Butane	Propylene Dichloride
Ethylene Dichloride	Propylene
Flourocarbon Refrigerants	Pyridine
Hydrocarbon	Solvent
Mixed Xylenes	Solvent Mixture
n-Heptane	Transformer Oil

Molecular Sieves have also been tested in many others systems—systems as difficult to dry as water-alcohol azeotropes, ketones, ethers, and so on. Performance data are available on request.

If you are looking for a way to dry a liquid stream—or if you need to improve the performance of an existing drying system—let us show you how Molecular Sieves can work for you. When you order your Molecular Sieve Drier, we will work closely with the equipment manufacturer of your choice. Write, wire or phone today, Molecular Sieves Dept., Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Telephone YU 6-6200, Ext. 365.

Linde TRADE MARK MOLECULAR SIEVES

UNION CARBIDE

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Industry schools

from page 110

fact that there were five rehearsals for the meeting, the first of which was five weeks prior to the meeting. The subject was broken down into several presentations, each lasting from fifteen to twenty minutes, each followed by a fifteen-minute discussion period. After the technical presentation, the "students" were taken on a detailed inspection trip through the Belle ammonia plant; the program concluded with a final discussion period.

No aspect of ammonia production was neglected. From a description of the development of ammonia production at Du Pont, the talks proceeded to a "nothing-held-back" treatment of methane reforming practice and of synthesis gas manufacture and purification. The morning session concluded with talks on ammonia synthesis catalysts and the design of the synthesis unit itself. After lunch, the talks turned to corrosion and waste control, operation of the plant, and to

H. S. Hopkins (center) of DuPont's Belle Works makes a point. Listeners are: S. D. Smith of DuPont's Sabine River Works (left), and John Prados of the University of Tennessee (right).

a consideration of economic and marketing aspects of ammonia production.

Special bonus for each of the participants was a bound volume containing all of the talks as well as reproductions of the diagrams and other visual aids which had been used as slides during the presentation.

Ion exchange "School"

Ion exchange is well on the way to becoming a standard unit operation and a recognized part of every chemical engineering curriculum. This was brought out forcefully at a one-day symposium sponsored by the Rohm and Haas Co. in Philadelphia in cooperation with a local A.I.Ch.E. committee.[3]. This was the 2nd annual industry-sponsored school for chemical engineering teachers for the Middle At-

continued on page 114

● With the ever increasing demand for ethylene, now is the time for producers to take a long look at naphtha—a raw material that is not only practical but rapidly becoming more and more plentiful.

● Kellogg offers an unequalled background in processes and plants for the production of high-purity ethylene directly from naphtha and other liquid petroleum fractions, as well as for the recovery of ethylene.

● Utilizing its unique steam pyrolysis process, Kellogg has engineered and built nine ethylene-from-naphtha plants for leading chemical manufacturers in various parts of Europe.

● In the U.S.A. Kellogg has engineered and built a naphtha cracking plant on the Gulf Coast, and has made several economic studies in this country on naphtha and other liquid feedstocks for ethylene.

● Kellogg welcomes the opportunity to discuss with you in detail the many advantages of its steam pyrolysis process.

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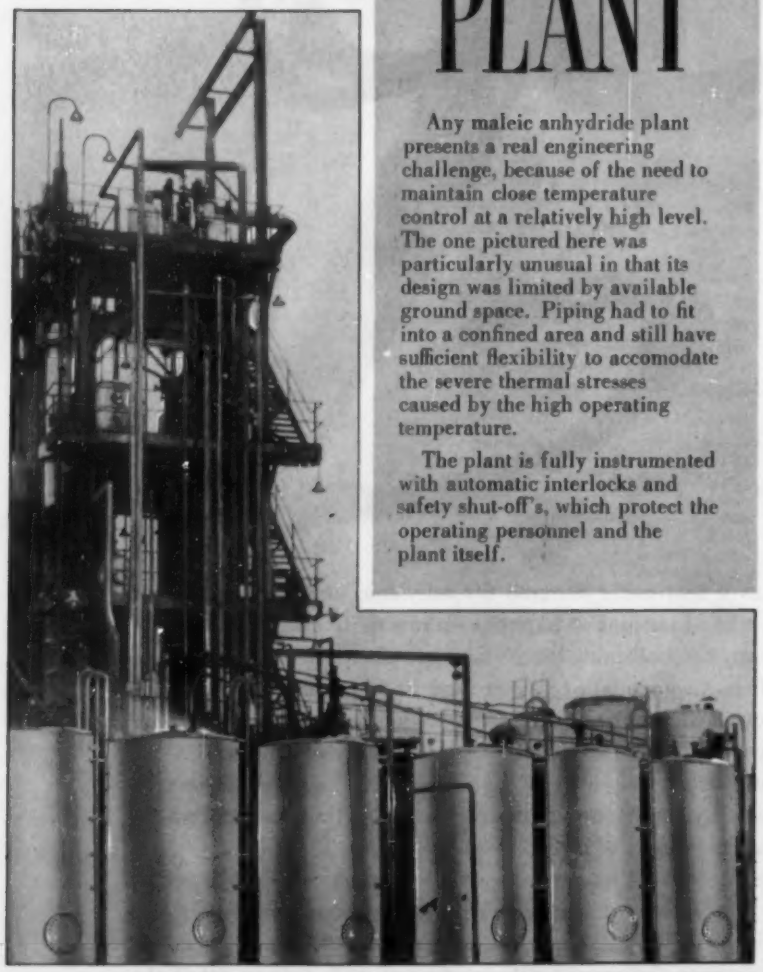
an unusual

MALEIC ANHYDRIDE PLANT



Any maleic anhydride plant presents a real engineering challenge, because of the need to maintain close temperature control at a relatively high level. The one pictured here was particularly unusual in that its design was limited by available ground space. Piping had to fit into a confined area and still have sufficient flexibility to accomodate the severe thermal stresses caused by the high operating temperature.

The plant is fully instrumented with automatic interlocks and safety shut-off's, which protect the operating personnel and the plant itself.

For further details on maleic anhydride plants, or any other chemical plant, contact I★P★E's Process Plants Division, Dept. D

I·P·E PRECISION ENGINEERED SERVICE

INDUSTRIAL PROCESS ENGINEERS

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In the lecture room — DuPont, Belle, West Va.

Industry schools

from page 112

lantic area, and also formed part of A.I.Ch.E. educational projects activity.

The purpose of the school was double-barrelled: not only to highlight ion exchange as a unit operation, but also to indicate areas where academic research would be beneficial. In this vein, talks were given by O. H. Loeffler on *The History of Ion Exchange*, by E. F. Meitzner on *Ion Exchange Resin Synthesis*, by R. Kunin on *Physical Chemistry of Ion Exchange*, by G. Bodamer on *Applications of Ion Exchange*, by N. W. Frisch on *Fundamental Engineering Aspects of Ion Exchange*, and by F. X. McGarvey on *Engineering Practices in Ion Exchange*.

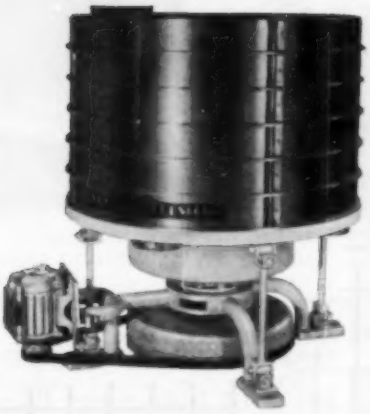
The school, attended by 22 chemical engineering teachers from 8 colleges and universities, concluded with a visit to ion exchange manufacturing facilities at the Rohm & Haas plant.

Process economics

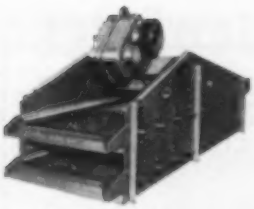
The role of economics in long-range problems was the theme of the ninth industry-sponsored school to be held in the Gulf Coast area. Host company for the school, which was attended by 20 faculty members from 5 schools, was American Oil Co. at Texas City. Feature of the afternoon session was the working out of two specific practical problems: the optimum split between furnace duty and exchanger surface for heat recovery; and the necessary economic incentive for installation of a hexane isomerization unit. American Oil Co. personnel who acted as instructors were J. F. Horner, F. E. James, E. A. Siegman, A. W. Goodwin, and D. A. Duke[4].

[3]*V. W. Uhl, Drexel Institute; A. E. Humphrey, University of Pennsylvania; L. Maus, Jr., Lehigh University.*

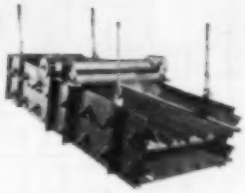
[4]*The original impetus for organization of the school came from K. A. Kobe of the University of Texas, a former chairman of the A.I.Ch.E. Chemical Engineering Education Projects Committee who first started the ball rolling in the Gulf Coast area in 1950.*



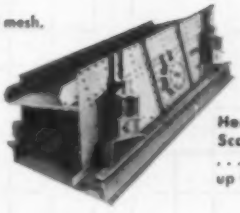
Stainless Steel Gyratory Screen
. . . for size classifications 2 to 325 mesh.



Horizontal Screens
. . . for separations up to 2½ inches.



Small Inclined Screens
. . . for separations 1½ inches to 40 mesh.



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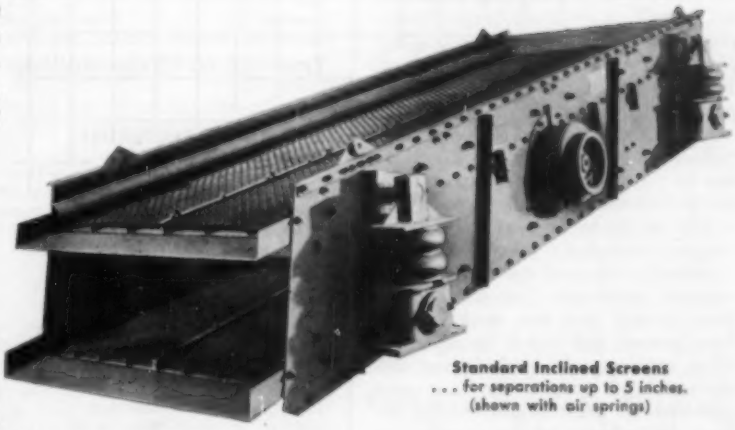

Standard Inclined Screens
. . . for separations up to 5 inches.
(shown with air springs)

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Ductile iron in use for chemical pumps

Ductile iron is under evaluation testing as a material of construction for the chemical process industries. Here is a progress report and a summary of the advantages expected, with emphasis on corrosion and abrasion resistance.

Ductile iron appears to offer to the chemical industry the corrosion-resisting advantages of cast iron and, at the same time, the strength and ductility of steel. Complete evaluation of the corrosion resistance of ductile iron has not been completed, but the indication is that, in a great many cases, it will be comparable to that of ordinary gray iron. In addition, the wear resistance of ductile iron is an advantage in the handling of slurries where abrasion is a major problem.

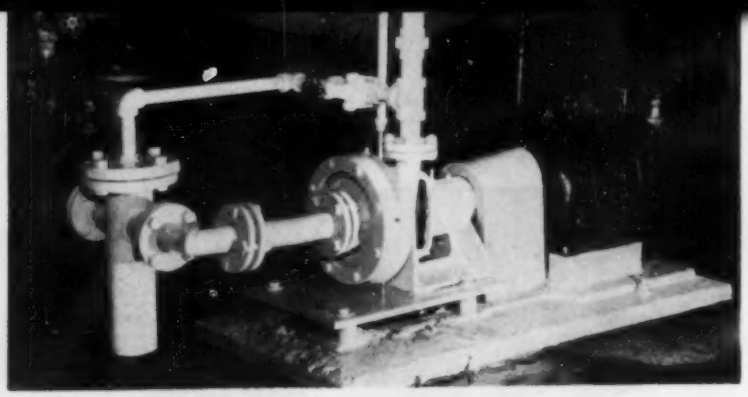
Probably, according to Worthington Corp., the two types of ductile iron most adapted to pumping equipment are Type 60-45-10 and Type 80-60-03. Type 60-45-10 is used when ductility is the prime consideration, and Type 80-60-03 when extreme wear resistance is required.

Thermal shock test

A Worthington ductile iron chemical pump (see picture) was subjected to thermal shock tests before being placed in service in a large chemical plant. The pump is constructed of Type 60-45-10. The casing of the pump was heated to about 300°C with an acetylene torch and then quenched with cold water. No damage to the casing was apparent. The pump was then hooked up to steam at 165 lb./sq. in. and, with the steam running through the pump, was again quenched with cold water. The only damage noted was that the suction head gasket and the packing had been burned and had to be replaced. After replacing the packing and the suction head gasket, the unit was operated on plant liquids within an hour. No rubbing of the impeller on the suction head or casing was noted.

Test results indicate that a factor of safety is introduced by the fact that the casing of a ductile iron pump is not liable to fracture during a plant fire. Ordinary gray cast iron would fracture, feeding solvents or other flammable liquids to the flames.

—R. R. Rhodes



A Worthington ductile iron chemical pump

Two types of DUCTILE IRON

Type—60-45-10 specifications:

ASTM A339-51T
Ordnance MIL-I-11466 (ORD), Class 5
AMS #5315 (which requires 15% min. elongation and 2.89% Si. max.)

MECHANICAL PROPERTIES:

	Specified (Min.)	Typical Range
Tensile Strength—psi	60,000	60,000 to 80,000
Yield Strength—psi	45,000	45,000 to 60,000
Elongation—% in 2 in.	10.0	10 to 25
Brinell Hardness	—	140 to 190
Charpy Impact (unnotched)—Ft. Lbs.	—	60 to 115

Creep Strength (1% extension in 10,000 hrs.) at 800°F.—16,000/27,000 psi (higher levels achieved with alloys).

STRESS RUPTURE
100 hrs. at 800°F.—30,000/35,000 psi
1,000 hrs. at 800°F.—25,000/27,000 psi
100 hrs. at 1,200°F.—3,300/3,400 psi
1,000 hrs. at 1,200°F.—2,200 psi

CHEMICAL COMPOSITION:

	Nominal	Typical Range
Total Carbon	3.6	3.4/4.0
Silicon	2.5	2.0/2.75
Manganese	0.3	0.2/0.6
Phosphorus	0.06	0.08
Nickel	—	0/1.0
Magnesium	0.05	0.02/0.07

CHARACTERISTICS:

Maximum toughness and machinability. Weldability is second only to that of austenitic grade. Structure essentially ferrite achieved in the as-cast condition or by annealing. Capable of being flame or induction hardened although not as readily as type 80-60-03. Types 60-45-10 and 80-60-03 are the most popular types.

APPLICATIONS:

Pressure castings—valve and pumps bodies, compressor heads, pipe, fittings. Shock resistant parts for automotive, agricultural, machine use—clamps, railroad journal boxes, gear housings, tractor hitches, manifolds, axle pivot housings, fan and wheel hubs, electric motor frames.

Type—80-60-03 specifications:

ASTM A339-51T
Ordnance MIL-I-11466 (ORD), Class 4
AMS #5316

MECHANICAL PROPERTIES:

	Specified (Min.)	Typical Range
Tensile Strength—psi	80,000	90,000 to 110,000
Yield Strength—psi	60,000	60,000 to 75,000
Elongation—% in 2 in.	3.0	3.0 to 10.0
Brinell Hardness	—	200 to 270
Charpy Impact (unnotched)—Ft. Lbs.	—	15 to 65

Creep Strength (1% extension in 10,000 hrs.) at 800°F.—11,000/25,000 psi (higher levels achieved with alloys).

STRESS RUPTURE
100 hrs. at 800°F.—40,000/54,000 psi
1,000 hrs. at 800°F.—30,000/40,000 psi
100 hrs. at 1,200°F.—3,800/4,800 psi
1,000 hrs. at 1,200°F.—2,400/2,900 psi

CHEMICAL COMPOSITION:

	Nominal	Typical Range
Total Carbon	3.6	3.3/3.8
Silicon	2.5	2.0/3.0
Manganese	0.4	0.2/0.5
Phosphorus	0.06	0.08
Nickel	—	0/1.0
Magnesium	0.05	0.02/0.07

CHARACTERISTICS:

Maximum strength in as-cast condition; excellent wear resistance, good machinability and toughness. Essentially pearlitic structure which responds readily to flame or induction hardening. Sometimes cast against a chill to provide a carbidic, abrasion resistant surface.

APPLICATIONS:

Wear and strength applications for automotive, diesel, agricultural, heavy machinery, mining, paper, textile and other related industries. Applications such as hammer anvils, press side frames, beds, shakeout tables, impellers, levers, gears, crankshafts, sheaves, cams, rolls, dies, pinions, pistons, jet engine burner support rings.

New Invention Cuts Waste Disposal Costs By Two-Thirds in Chemical Processing Plants

Industry Cost Averages May Be Lowered Soon

If your plant is average, you're probably spending between .55 and .85 cents for every cubic yard of waste or trash moved to the disposal area . . . not including truck operation costs.

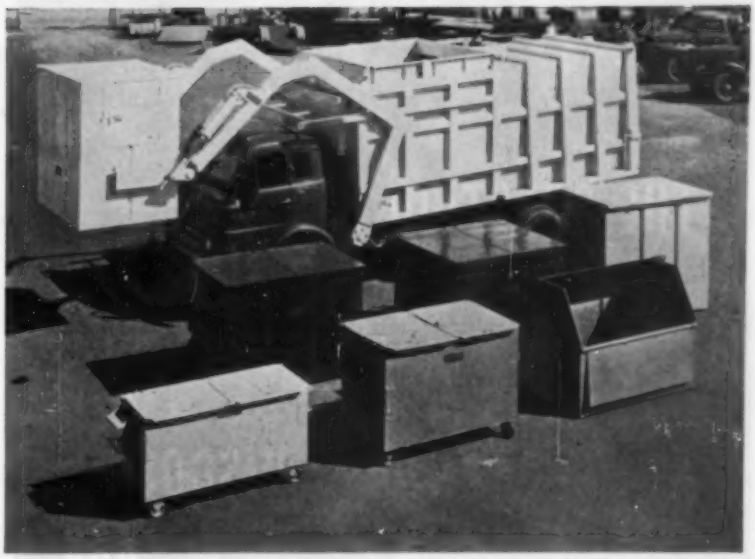
A recent development, the DEMPSTER-DUMPMASTER self-loading packer, promises to cut direct disposal costs to a new industry low of .07 to .16 cents per cubic yard for volume producers.

This new approach is an extension of the widely-established DEMPSTER-DUMPSTER System, in that it employs detachable waste storage containers. However, instead of carrying each container to the disposal area for dumping, the new machine empties many containers into its body, where the material is compacted to a fraction of its former volume. This permits per-trip payloads of 50 to 100 cubic yards of loose material, depending on its characteristics.

Multiple exposure photo shows dumping of 6 cu. yd. container.

How it Operates

The one-man Dumpmaster makes its rounds from container to container. Approaching, the driver engages lifting channels on the container's sides with the clearance arms. From controls in the cab, or remote controls at the front bumper, the container is lifted and rotated, discharging waste into the packer body. The material is hydraulically compacted while enroute to the next location. Containers may also be handled from docks or below grade. The safety clearance arms never pass the cab windows, eliminating possibility of driver injury.



The newly developed DEMPSTER-DUMPMASTER is shown with the seven basic containers it serves. Being hoisted is a 6 cu. yd. model. On ground are 1, 2, 3, 4 and 5 cu. yd. designs. Open container is used for hand-loading service.

New "Tracking" Caster Developments Make Plant "Container Trains" Practical

To whip the high cost of moving refuse outside, many plants are going to "container trains." Using special casters and couplers, eight to ten containers are towed by "plant mules" to inside generation points where an empty is dropped off and the full one is coupled on. Outside, the containers are uncoupled and automatically emptied by the waiting DUMPMASTER.

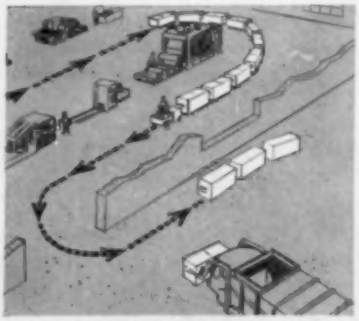


Diagram shows containers, in train, being hauled outside for emptying.

Many Designs Available

Standard and special-purpose containers, ranging from one through six cubic yard capacity, with or without casters, are available. The two cubic yard container above holds the equivalent of over 12 30-gallon trash cans.

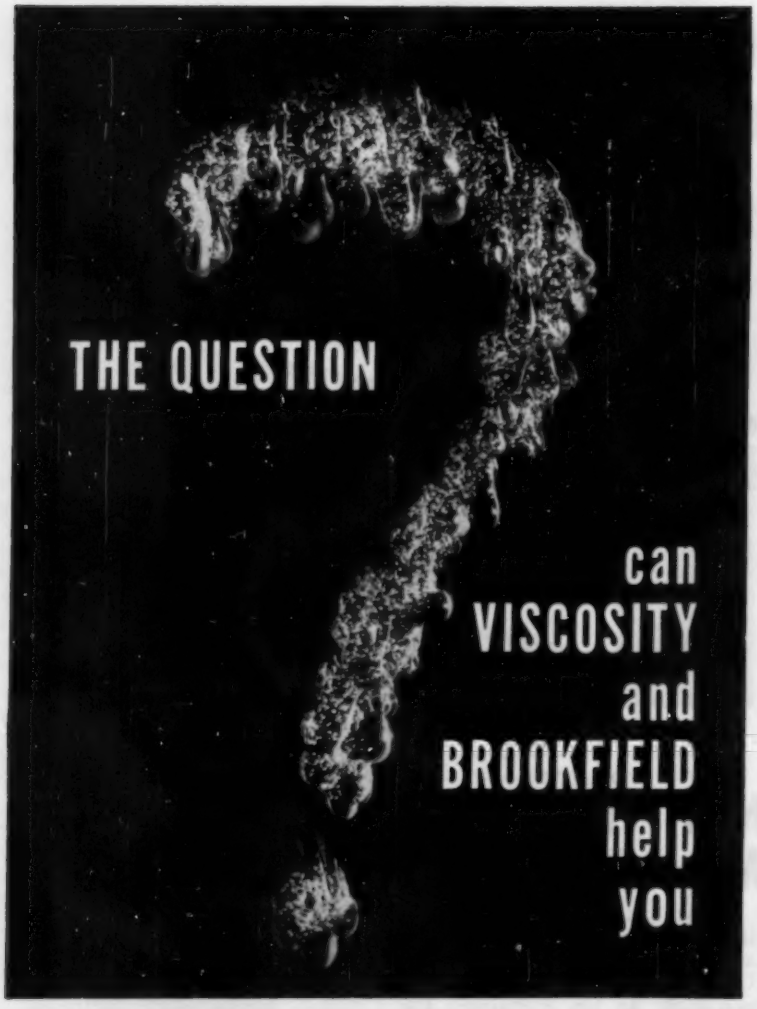
Cost-Finding Book Offered

Write for the free 40-page book, "How to Cut Waste Disposal Costs," offered by the manufacturer. It contains cost-finding formulas, solutions to problems, case histories, industry average costs, etc. Equipment demonstrations arranged on request.

Mfd. by Dempster Brothers, Inc.

DEMPSTER BROTHERS

KNOXVILLE, TENN., DEPT. CH-9



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Large terephthalic acid plant for England

Imperial Chemical Industries contracts for 30 million lb./year plant, will expand production of Terylene polyester fiber and Melinex polyester film

The giant Wilton Works of Imperial Chemical Industries (present capital investment estimated at $336 million) will be the site of a new terephthalic acid plant, to be designed by Scientific Design Co. of New York. The new facilities will begin operations in 1960 and will raise fiber-making capacity to about 50 million lb./year at the Wilton Works.

Polyester fiber was discovered in England in 1941. Patent rights were assigned to the Calico Printers Association but were declared secret by the British Ministry of Supply for the duration of the war. At the end of the war, Imperial Chemical Industries received exclusive licenses for the world excluding the U.S. United States rights were bought outright by Du Pont from the Calico Printers Association.

An Operating Guide Computer System —claimed to be the first installation of its kind in the process industries— has been successfully placed on line at a catalytic cracking unit at Esso's Baton Rouge Refinery. Engineered and constructed by Leeds & Northrup, the system measures 160 process variables, of which 27 are computed operating guides such as catalyst circulation rate, carbon burning rate, material balance, etc. According to Esso, the system, in addition to improving process performance, will be used to develop techniques for ultimately "closing the loop."

Five million cubic feet of oxygen per month, in addition to high-purity nitrogen, will be produced in Kansas City in a new plant of Air Reduction Sales Co. slated for completion in December, 1958. #

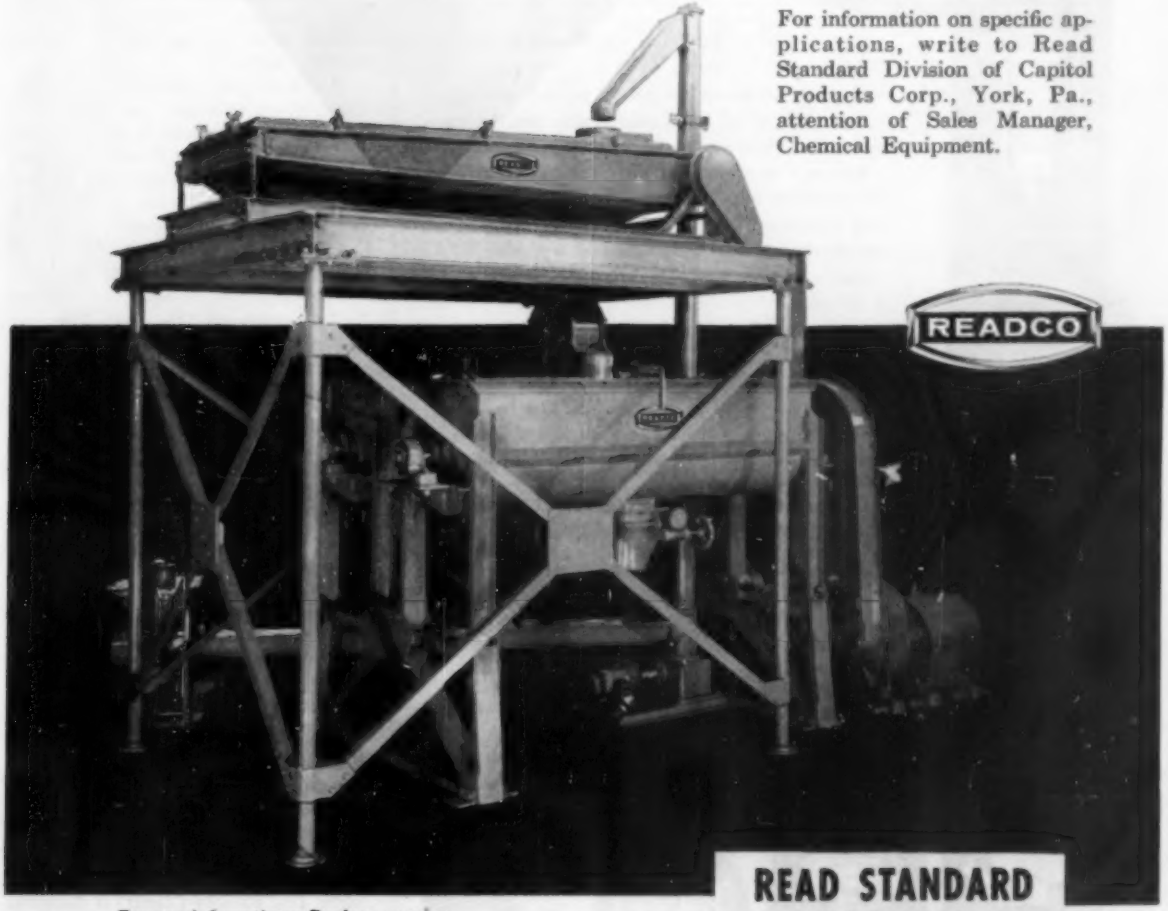
Sift it Fine and Fast

...right into the mixer

Reciprocating vertical and rotary motion of the screen in Readco vibrating sifters make it possible to sieve and aerate powdered and granular materials at high speed with maximum control. The illustration below shows the sifter mounted on twin Readco ribbon mixers. Here screw conveyors and screw elevator carry materials to the sifter, which discharges directly into the mixers.

Readco sifters are built in capacities to suit any production requirement, with ready adaptability to materials handling systems.

For information on specific applications, write to Read Standard Division of Capitol Products Corp., York, Pa., attention of Sales Manager, Chemical Equipment.



For more information on Readco processing equipment for the chemical industry, see Chemical Engineering Catalog, pages 1567 to 1574D.

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York, Pennsylvania

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NOISE and PULSATION CONTROL DEVICES

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For Hydraulic Shock and Surge

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Gas and Diesel Engines and Compressors

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Since the first Everett device was installed in 1921, the line of products has steadily grown to include pulsation and noise-control equipment for practically every need in refineries, chemical and steam plants, engine and compressor stations and aircraft jet engine test equipment.

Because of the tremendous need in the noise and pulsation abatement fields, we are now, through Pulsation Controls Corporation, a company licensed by Everett, producing and distributing these fine products for both domestic and foreign markets. These unique devices employing Everett patents and built without the use of moving parts have outperformed all others in efficiency and with the least pressure drop.

Engineering brochures and case histories have been prepared for you describing each product. You are cordially invited to request data on any or all Everett devices. By comparison you will be amazed with the performance!

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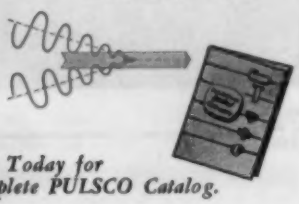


Send Today for Complete PULSCO Catalog.

U.S. Exhibits Tracer Techniques at Geneva

Latest U.S. techniques in manufacture and use of radioactive isotopes in biochemical research feature the AEC exhibit at the International Conference for Peaceful Uses of Atomic Energy now in full session at Geneva. The AEC radiochemical exhibit consists of three distinct operations. In the first phase, two drugs are "labeled" with radioactive isotopes: Isoniazid with Carbon 14, and Diamox with Sulfur 35. Radioautographs are being exhibited to show the effect of these drugs on the central nervous system and as a check on drug concentration in various parts of the body.

In the second phase, a number of organic materials have been tagged with tritium, or radioactive hydrogen, by direct exposure to the gas. The third phase demonstrates assaying of tritium and Carbon 14 in various organic materials.

For maximum visibility of radiochemical operations, the laboratory equipment at Geneva is all arranged in a circle 22 ft. in diameter. A circular balcony overhangs the laboratory to give observers a bird's-eye view of all activity below.

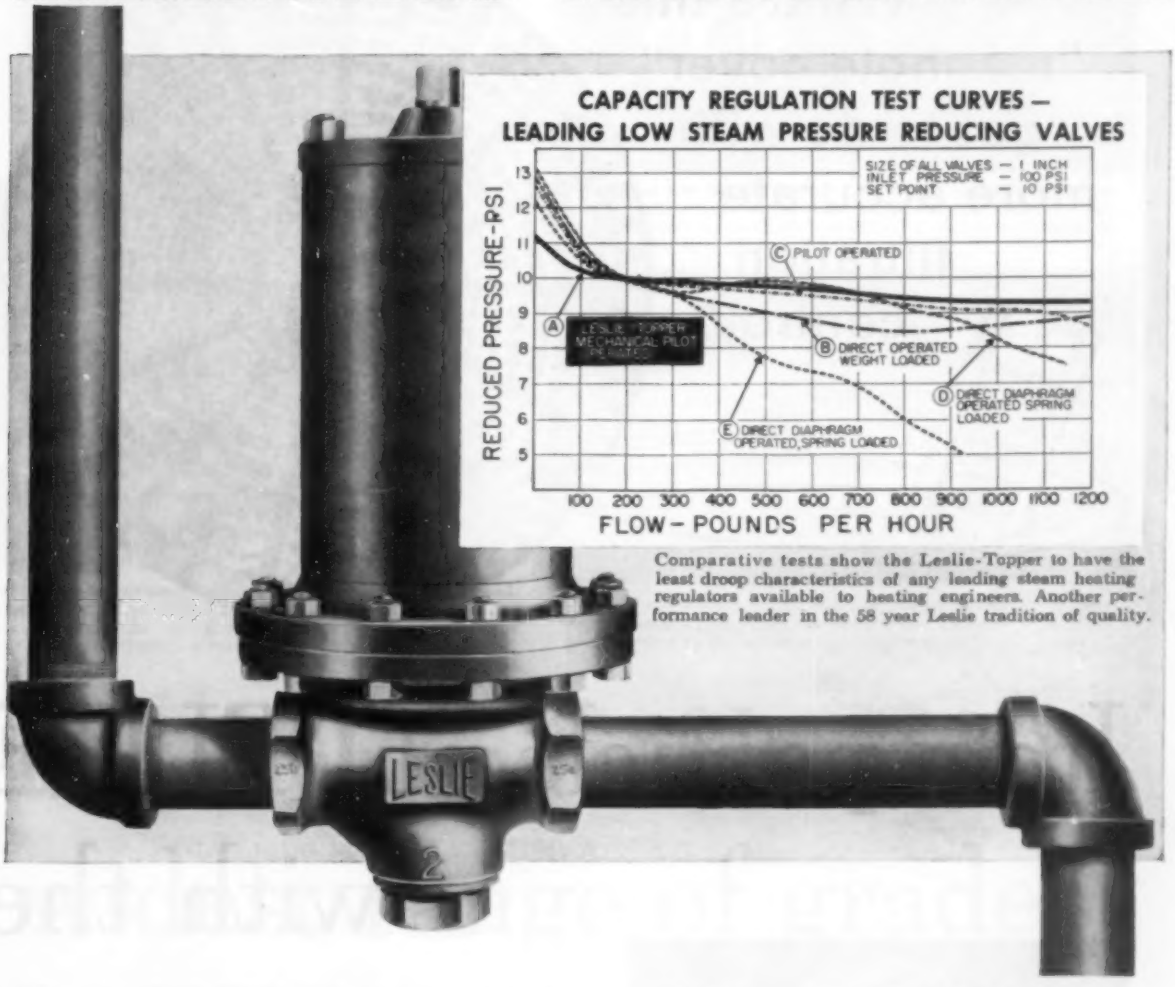
Laboratory equipment, fabricated largely from stainless steel for easy decontamination, was loaned for the exhibition by S. Blickman, Inc. of Weehawken, N. J., at AEC request.

A reactor safety "fuse" which automatically shuts down high-power nuclear research reactors, if operating control is lost, has been designed, built, and successfully tested for the AEC by Atomics International. In a test, the fuse prevented the reactor power from rising excessively during a severe transient in which the rate of power increase was tripling each one-hundredth of a second. The fuse terminated the power surge at a level 25 times lower than the reactor would have reached without the device. #

The effect of extreme nuclear conditions upon fast reactor fuel elements will be investigated in a reactor to be completed this year at the AEC's National Reactor Testing Station at Idaho Falls, Idaho. The Transient Reactor Test Facility (Treat) is designed to deliver a high-intensity, short-duration pulse of nuclear energy without damage to the facility itself. #

revolutionary pressure reducing valve with mechanical pilot out of steam path

ELIMINATES MAINTENANCE



Comparative tests show the Leslie-Topper to have the least droop characteristics of any leading steam heating regulators available to heating engineers. Another performance leader in the 58 year Leslie tradition of quality.

Now . . . a mechanical pilot operated reducing valve with direct operated simplicity and steam pilot accuracy . . . proven in comparative tests with other leading regulators a new concept in maintenance-free steam pressure reduction . . . the LESLIE-TOPPER

- Inlet pressures from 7 to 250 psi — reduced pressure ranges from 2 to 35 psi.
- Sizes ½", ¾", 1", 1¼", 1½", and 2".
- Piloting device entirely outside the path of steam.
- No dirt catching or close fitting parts — Use it for intermittent, continuous or standby service with complete confidence.
- Packless construction.
- Long life, long travel, *metal* diaphragm.
- Single-seated stainless steel main valve, hardened to 500 Brinell, seats on renewable *stellited* stainless steel seat ring for tight shutoff.
- No auxiliary operating air required.

All of this adds up to new reliability, freedom from maintenance and shutdown time. All of these extra quality features are available at less initial cost than any steam pilot or direct operated regulator you would endorse with your specification.

Eliminate your steam heat reducing valve problems this year, this heating season; write *now* for all the facts, including complete capacity-regulation data — or phone your Leslie representative. You'll find him listed in your classified directory.

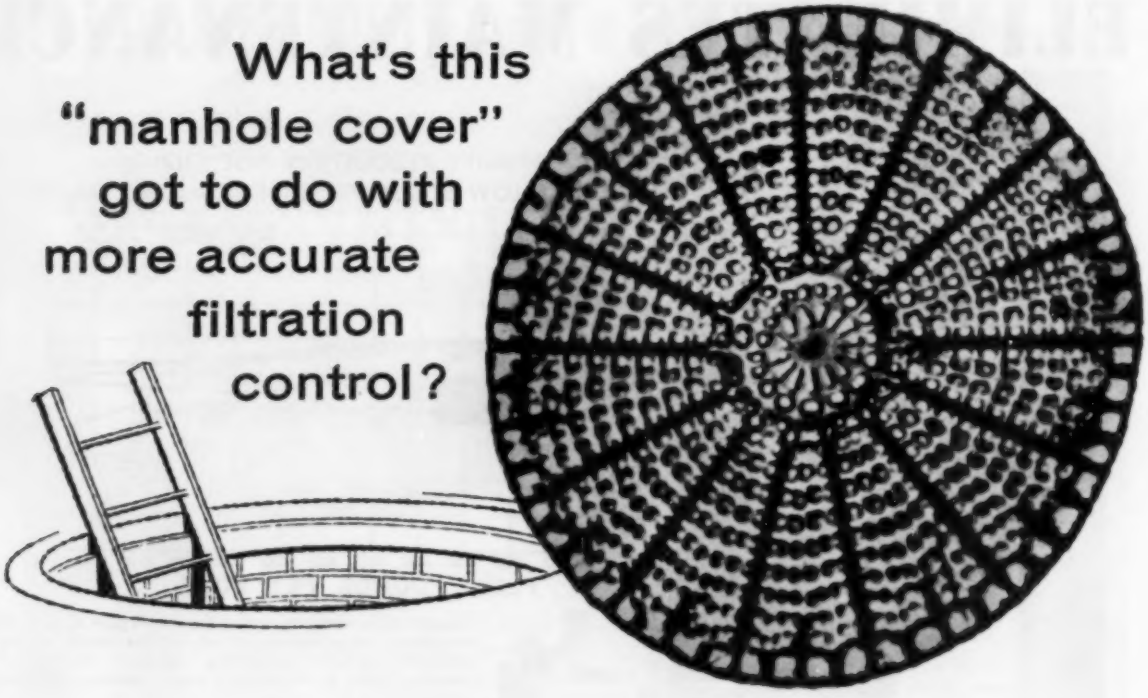
TRADE LESLIE MARK

REGULATORS and CONTROLLERS

LESLIE CO., 241 Grant Avenue
Lyndhurst, New Jersey

THIS "MANHOLE COVER" is really a magnification of *Arachnoidiscus ornatus*, one of the hundreds of different intricate particles that make Celite such an effective filter aid.

What's this "manhole cover" got to do with more accurate filtration control?



It's a particle of CELITE with the

The photomicrograph at left shows the wide variety of particle shapes and sizes in a typical Celite sample. By carefully controlling the proportions of particle sizes, the most complete range of grades is obtained.

Johns-Manville CELITE

Celite's wide range of grades permits precise control of several different filtration operations in the brewing of beer and ale. These include various ruh beer filtrations, wort filtration, final beer polishing and purification of brewing and bottle wash waters.

In industry's modern research laboratories, Celite filtration has proved itself an indispensable tool. Special grades of Celite have been developed that are particularly effective in analytical methods requiring filtration or chromotographic study.

In the manufacture of lubricating oils, Celite filter aids completely remove bleaching clay from the oil itself and also clarify the many additives used by the industry.

-the diatomite filter aid widest range of grades

Need maximum clarification? Use Celite* Filter-Cel. Or does your filtration require the fastest flow rates? Then use Celite 545. In addition, there are 7 more intermediate grades plus many special grades produced for specific applications. Thus, with Celite, you can establish the exact balance of clarity and flow rate that your process requires. No other diatomite gives you such a wide choice of grades.

Celite also gives you other important advantages over competitive filter aids. Its lower wet density provides greater surface coverage per pound. This means substantial savings because six bags of Celite actually do the work of seven bags of other diatomites.

And Celite is uniform. Every pound of Celite comes from the world's largest and purest commercially available diatomite deposit. Every pound is processed and graded at the same plant under the same conditions. Yet, with the large inventory maintained at the plant and Johns-Manville's nationwide network of warehouses, you're assured of fast, sure delivery.

So, if filtration belongs in your processing operations, it will pay you to call in your local J-M Celite engineer. Backed by Johns-Manville's research facilities and years of practical diatomite experience, he can help you with your filtration problems. Call him today or write Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

Diatomite Filter Aids

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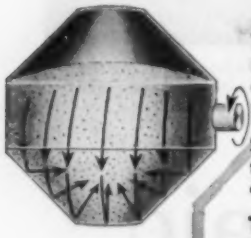
For QUICK, COMPLETE, EVEN DRYING

use the Paul O. Abbé ROTA-CONE VACUUM DRYER



The gentle agitation of the Paul O. Abbé Rota-Cone Vacuum Dryer gives the material quick, even, complete drying of the entire batch. No wet and dry spots can occur as with some other types of dryers.

So gently is the material agitated, that there is no contamination or degradation of even the most delicate materials. Yet the entire load is kept constantly in motion so it dries uniformly.

The Paul O. Abbé Rota-Cone Vacuum Dryer can also be used as a Cone Blender. You get the use of two machines for the price of one! The Paul O. Abbé Rota-Cone action produces a perfect blend.

The machine is easy to clean, since there are no agitators or baffles. There is no dust, since an internal filter is used.

The Paul O, Abbé Rota-Cone is safe. No poisonous or otherwise hazardous fumes can escape.

If you are not now using this Rota-Cone, your drying operations suffer.

Write us now for folder illustrating and describing in detail, the Paul O. Abbé Rota-Cone Vacuum Dryer. Just use the coupon below. No obligation.

Paul O. Abbé Inc.
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Please send me illustrated folder describing in detail the Paul O. Abbé Rota-Cone Vacuum Dryer.

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Company.....

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PAUL O. ABBÉ INC

271 CENTER AVENUE LITTLE FALLS, NEW JERSEY

1908 JUBILEE 1958

A.I.Ch.E. Jubilee honored by Ohio Governor

"WHEREAS, the insatiable desire for truth and new knowledge which is the cornerstone of science and engineering and which transcends all forms of bias and prejudice may thus contribute direction and inspiration toward the achievement of international peace; and

WHEREAS, chemical engineering adapts nature's resources for man's benefit—thus enhancing our society and our economy. . . ." So said C. William O'Neill, Governor of Ohio, proclaiming Chemical Engineering Week in Ohio on the occasion of the recent A.I.Ch.E. Jubilee Meeting in Philadelphia.

Shown at the proclamation signing are (left to right); Joseph H. Koffolt, chairman of the Chemical Engineering Department at Ohio State University; C. William O'Neill, Governor of Ohio; and George F. Sachsel, Battelle Institute and chairman of the Central Ohio Section of A.I.Ch.E.

A major carbon bisulfide plant is on stream in Australia, at Newcastle, N.S.W. Costing more than $1.5 million, the plant was erected by Hunter River Chemical, a subsidiary of Australian Cream Tartar Co., in which Stauffer Chemical of New York has a 34% interest. Know-how, and construction and start-up supervision were furnished by Stauffer engineers. #

A new 32,000-barrel refinery in Honolulu will be in full operation by the end of 1960, says Standard Oil of California. #

APPLIED CRYOGENICS

...does so many jobs so well!

Separation of Gases

The dramatic impact of gas separation technology on world industry is notable because it represents a unique combination . . . hitherto unavailable process results coupled with a strong economic advantage. Oxygen, the outstanding example, is a highly reactive chemical, 99+% pure, available in unlimited quantities for a few dollars per ton . . . often less costly than coal or crushed rock. "Dirt cheap" is sometimes literally true of oxygen.

Besides air, many other gaseous mixtures are separated; impurities in any concentrations are economically removed or reclaimed. Gases commonly recovered include: argon, carbon monoxide, ethylene, fluorine, helium, hydrogen, krypton, methane, neon, nitrogen, oxygen and xenon.

Energy Storage

High energy gases are liquefied and transported economically without loss at maximum density. Methods for handling liquid ethylene, fluorine, methane, oxygen, oxygen difluoride and ozone are outstanding examples of this art.

Low temperature stabilization of free radicals promises effective storage and release of energy from cryogenic environments. Synthesis possibilities via controlled free radical reactions stir the imagination.

Sensitive Measurements

Recently, practical application has been made of the extremely responsive properties of certain materials at very low temperatures. Infrared radiation from very distant sources may be measured and interpreted for military detection purposes. Superconductivity has made possible miniaturization of computers. Masers (Microwave Amplification by Stimulated Emission of Radiation), are the heart of super-cold circuits which control and amplify the faintest possible signals with superb fidelity and incredibly low self-generated noise.

Development of Basic Data

Fundamental information about the properties of materials is discovered by the use of extreme temperature environments for conducting physical measurements.

CRYOGENIC PROCESSING INVOLVES SEVERAL BASIC FUNCTIONS

Making Refrigeration

Often, particularly in separation processes, the process fluid may also be used as its own refrigerant. The manufacture of refrigeration to support the process may be accomplished by compression and aftercooling coupled with expansion of gas, either adiabatically or performing work, as in a turbine or engine. External refrigeration systems employing freon, ethylene, nitrogen and helium are commonly used.

Using Refrigeration

Process operations include virtually all the standard unit operations such as distillation, fractional condensation, adsorption, filtration, pumping, absorption, solvent extraction, fractional crystallization, etc. Magnification of differences in physical properties at low temperatures makes some processes work which appear impossible based on ambient temperature data.

Conserving Refrigeration

Operating at temperature levels where one ton of refrigeration requires between 50 and 100 hp for its creation, the conservation and recovery of refrigeration from process fluids is extremely important. Cryogenic equipment using gas-to-gas heat exchangers effectively handles flow volumes of gases ranging from tiny to tremendous. Such gases may undergo temperature changes well over 300° in a single exchanger with a driving force as low as 5° F.

Recoveries

Recoveries are important also. In optimizing costs, some processes favor large flow quantities at low pressures for making sufficient refrigeration. In other cases, smaller flow volumes, higher pressures and complex refrigeration processes become optimum.

APPLYING CRYOGENICS REQUIRES SPECIALIZED KNOWLEDGE AND EXPERIENCE

Until fairly recently, the application of cryogenics was limited to the separation of gases and was in many respects a practitioner's art rather than an engineering science. Since 1940, Air Products has devoted itself entirely to the development of basic data, engineering standards, design, construction and operating principles essential to the effective transformation of an infant science to a mature technology.

EVALUATING CRYOGENICS FOR YOUR NEEDS IS EASY

A letter, a wire or a phone call to J. E. Nachod at Air Products will quickly bring you the services of an experienced cryogenics engineer who can help you interpret the potential contribution of applied cryogenics to meet your needs. A vast storehouse of information may be put to your use instantaneously for:

1. Evaluation of existing processes to suit your specific needs.
2. Development and adaptation of new processes as required.
3. Over-the-fence supply of almost any gas on a guaranteed cost basis.

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EVERY ENGINEER will want a copy of this NEW BULLETIN

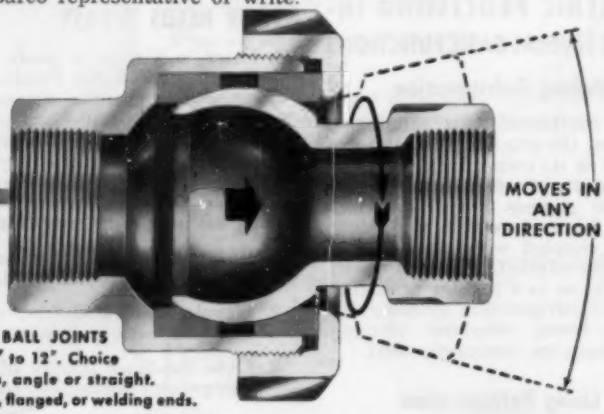
HOW TO SOLVE

PIPE EXPANSION PROBLEMS

CERTAIN distinctive characteristics and features make Barco Flexible Ball Joints particularly well-suited for solving many present-day plant piping design problems, especially for *Steam Service:*

1. **Ability to handle compound movement (where twisting is combined with thermal expansion and contraction).**
2. **Virtually no deterioration. Able to stay in service for years without repairs or maintenance. No lubrication.**
3. **No heavy pipe anchoring required. No "end thrust" developed under pressure. Minimum space needed for installation.**
4. **Maximum safety for high temperature applications. All-metal construction available. Special metals can be specified.**
5. **Basic design is pressure sealing against leakage and self-adjusting for wear. Suitable for steam pressures to 750 psi and higher.**
6. **Easy to engineer joints into piping to provide for any degree of flexibility, expansion, or movement required.**

New Bulletin No. 31 contains interesting diagrams showing how to solve many common pipe expansion problems EASILY, ECONOMICALLY. *Ask for a copy;* see your nearest Barco representative or write:



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industrial news

Atomic soap

Gamma ray-triggered reactions result in new classes of detergent materials

Esso Research and Engineering has used atomic radiation to produce synthetic soaps on an experimental basis. Cost of the radiation process promises to be competitive with conventional methods of making detergents, says Esso, since the radiation is required only to start up the chemical reaction. Once the reaction is "triggered", the radio-isotope giving off the gamma rays can be removed and returned to its storage cell.

In the experiments, described by Esso researchers at the Geneva Conference now in progress on Peaceful Uses of Atomic Energy, gamma rays emitted by cobalt-60 caused reaction of sulfur dioxide and oxygen with liquid paraffins. It is hoped that the new method may open up ways to make detergents on a large scale from paraffins less expensive than such aromatics as benzene and toluene, widely used today. Added attraction is that there is no danger of product contamination in the use of gamma rays.

Installation of a large spray dryer for the production of by-products from waste sulphite liquor will be a feature of a million-dollar expansion program which will double the waste liquor capacity at the Quebec plant of Lignosol Chemicals. The outsize dryer will be engineered and constructed by Bowen Engineering of North Branch, N. J. #

Prilled ammonium nitrate and ammonium-nitrate-limestone will be turned out in a new unit to be constructed by Ketona Chemical Corp. at Ketona, Ala. Design and construction will be by Chemical and Industrial Corp. of Cincinnati. #

A new process to produce extremely pure "electronics" grade silicon metal will be developed by Metal Hydrides, Beverly, Mass., under a renewal contract from the Air Force Cambridge Research Center. Contract value—$91,585. #

Production of glacial acrylic acid is underway at the newly-completed plant of B. F. Goodrich Chemical in Calvert City, Ky. Capacity is stated to be "several million pounds per year." #

SPROUT-WALDRON

Pointers

for Mixing and Blending • Size Reduction
Size Classification • Bulk Materials Handling • Pelleting and Densifying

Published in the interest of better processing by Sprout, Waldron & Co., Inc., Muncy, Penna.

BLENDING HCL AND STARCH POWDER

An assembly of horizontal batch mixers preceded by brush sifters had been installed for the mixing of diluted HCL acid and starch powder prior to converting the starch to dextrine. Results indicated quickly that thorough blending was needed.

Non-uniform distribution of acids and starch caused acid-rich nodules on the stock layer to be conveyed to the oven. Other portions were insufficiently treated. Two troubles resulted:

1. Those portions of the stock over-treated either carmelized or charred causing carbon specs.
2. Portions under-treated were not completely dextrinized.

When an adaptioneered S-W Intimate Blending System was installed, acids and starch were so completely blended that both types of troubles were entirely eliminated. Sprout-Waldron blending not only eliminates all lumps or nodules, but accomplishes such complete dispersion that individual particles lose their identity.

SW

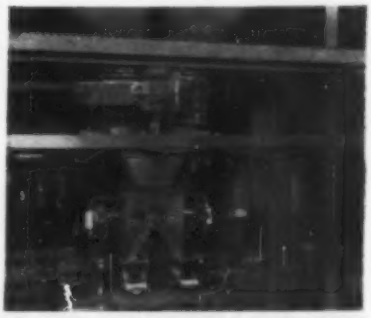
STOP DUST WITH S-W MULTI-TUBE FILTER DUST COLLECTORS

Operates under a vacuum so there is no outward leakage.
Compact, streamlined appearance.
Available for floor or hopper mounting.
Shaker handle facilitates cleaning of filter tubes.
Filter tubes easily removed for inspection.
Available in either 200 cfm or 400 cfm capacity.

To provide maximum plant cleanliness, prevent waste and eliminate complaints about dust, the Sprout-Waldron multi-tube dust collector is the most efficient answer.

The floor mounted Sprout-Waldron dust collector draws dust in through a connection in the side of the case. The hopper mounted unit utilizes the suction created to draw the dust-laden air from the complete hopper surroundings. A separate air inlet connection in the side of the case may be furnished so the dust from other equipment as well as from the hopper may be collected. Dust cannot leak out of the collector since the entire case is under vacuum during operation.

The clean air from either unit may be discharged directly into the room for conservation of heat or be blown to the outside through ducts when required. Each of the many special cloth filtered tubes have their own support grid and the complete tube assembly can be kept clear of dust for greater filtering efficiency at periodic shaking of the entire support plate.



Close up of Sprout-Waldron Richmond Gyro-Pedestal Sifter showing columnar construction which permits 360° rotation.

GYRO-SIFTERS HELP KEEP ABRASIVE WHEEL QUALITY HIGH

Maintaining uniform grain size in the mass production of resin-bonded abrasive wheels at Carborundum presented quite a problem. Operating sequence called for mixing the various size grains with the resin binder at a central location and then conveying by means of buckets to 86 molding stations. The buckets discharged the grain-resin mixture into surge bins situated over the wheel molding machines.

Troubles arose because the pressure sensitive nature of the resin-bonded granules led to the formation of oversized agglomerates, which had to be screened out or broken up to maintain uniform grain size. A variety of vibrating devices had been tried without success. Carborundum licked the problem by mounting 43 Gyro-Sifters at the discharge ends of the bins. Since the design of these sifters permits them to be rotated 360° this arrangement made it possible to use one sifter for two or more reserve hoppers.

The full story appears in S-W *Pointers*, Vol. 1, No. 3. Copy on request.

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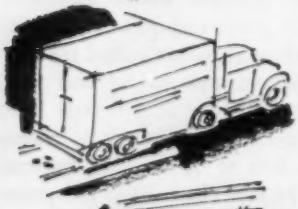

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QUALITY, OF COURSE—Individual loom operation and countless checks on mesh size and mesh count assure you of highest quality wire cloth when you specify Cambridge.

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OFFICES IN PRINCIPAL INDUSTRIAL CITIES

industrial news

A new leak-proof pump, the Hykinator made by American Dynamics, will be sold by the Bowen Corp. and its subsidiary, the Bowen Corp. of Canada. The new pump, aimed at the chemical process industries, has no rotating parts or seals, provides for instant variable flow control.

Prices on "Moplen" polypropylene, produced by Montecatini of Italy, have been reduced 7 cents per pound in the United States and Canada.

Cynamid's new Creslan plant in Santa Rosa, Florida, is scheduled to go on stream late this year. Finishing touches include extensive facilities for treatment and control of wastes to prevent pollution of Escambia Bay and other Northwest Florida waterways.

A major expansion at the Eldorado refinery of Monsanto's Lion Oil Division will increase crude oil thruput capacity from 29,000 to 33,000 barrels/day. New hydrodesulfurization, decarbonization, and tetramer units will go up, and existing vapor recovery facilities will be enlarged.

Slated for completion in August, 1959, are new ammonia and urea plants for the Cooperative Farm Chemicals Association of Lawrence, Kansas. Initial ammonia capacity will be 100 tons/day, urea capacity will be 30 tons/day. The synthesis loop, however, will be designed for 200 tons/day to provide for future expansion. Designer and builder is Chemical Construction Corp. of New York.

An improved process for manufacturing rubber-modified styrene is being used in new facilities at Monsanto's Plastics Division plant in Springfield, Mass.

Japanese ethylene oxide production capacity will be doubled by a new plant being designed for Mitsubishi Petrochemical by Scientific Design Co. of New York.

A new Houdry dehyrogenation process unit, designed to produce 36,000 metric tons per year of butadiene, has gone on stream at the Chemische Werke Huels, in Marl, West Germany. Process design was provided by Houdry, construction by Chemische Werke Huels.

Polymerization of a wide range of polyvinyl acetate emulsions is underway in a new plant at Slough, Bucks, England. Owned by National Starch Products of New York, the plant is operated by National Adhesives, Ltd., a British subsidiary.

TOWER PACKING

All the facts about HARSHAW *tellerettes*

Contained in this comprehensive booklet discussing the application of Harshaw Tellerettes to tower packing.

Subjects discussed at length (accompanied by pertinent charts)

1. The Tellerette Shape
2. Physical Characteristics
3. Lower Capital Investment and Operating Cost
4. Low Weight
5. Reduced Tower Height
6. Increased Tower Capacity
7. Support Plates
8. Corrosion Resistance
9. No Clogging

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Heavy water as ammonia plant "by-product"

Because of the low concentration of deuterium to hydrogen ocurring in nature (1 part in 7,000), and the large amount of heavy water needed for a nuclear power reactor, an economically feasible method for separating deuterium must be capable of handling large amounts of material at low unit cost. Even though many processes have been discovered which will separate these two isotopes, only a few will do so economically on a large scale. These separation methods include electrolysis, catalytic exchange, water distillation, and hydrogen distillation. Of these the first three have been used commercially while the last-mentioned has always been rejected until recently when plants were built in both Germany and France.

Heavy water produced by hydrogen distillation requires large quantities of purified hydrogen. However, it is not economical to produce hydrogen solely for the purpose of extracting deuterium. Benedict (*1*) has estimated that heavy water produced in this way would correspond to a cost of $75/lb. if commercial hydrogen gas were available at a cost of 50¢/M cu. ft. Consequently, a hydrogen-distillation deuterium plant is parasitic, taking a stream of hydrogen-rich gas produced for other purposes, extracting most of the deuterium and then returning the deuterium-depleted hydrogen to its original use.

Considering synthetic ammonia plants as a source of hydrogen, Hydrocarbon Research, Inc. (*2*) in 1950 concluded that for low-cost deuterium production the ammonia production rate should be at least 300 tons/day. Other sources of hydrogen were recognized but were deemed less suitable because of the greater cost of purification. Even so the impurities found in some hydrogen gas for ammonia synthesis are quite appalling since all must be removed before the hydrogen-distillation step. A typical composition is given as 92 - 94% H_2, 1 - 4% N_2, 0.5% CH_4, 2 - 4% CO, lesser amounts of CO_2, argon, helium, neon along with variable amounts of oxygen and water vapor.

The recent application of the Texaco partial oxidation process for making hydrogen in the manufacture of synthetic ammonia has made the parasitic hydrogen distillation quite a bit more attractive because of the higher purity of the synthesis gas. As noted on the flow diagram for this process, the most likely spot to remove the deuterium from the hydrogen gas is after the nitrogen wash tower because of favorable temperature conditions.

In this process two raw materials are used — air and natural gas. Air supplies the nitrogen and natural gas the hydrogen for the ammonia synthesis.

Filtered air is compressed to 125 lb./sq. in. gauge in centrifugal compressors, raised in pressure to 600 lb./sq. in. gauge, and then scrubbed with caustic. A pass through a chiller and through a bed of activated alumina prepares the air for the air separation plant. Here N_2 (99.99% pure) and O_2 are produced.

After preheating in a heat exchanger, the O_2 passes into the gas generator where it partially oxidizes the preheated and compressed natural gas. In the gas generator H_2 and CO are produced. With the addition of steam in a shift converter the CO converts to CO_2.

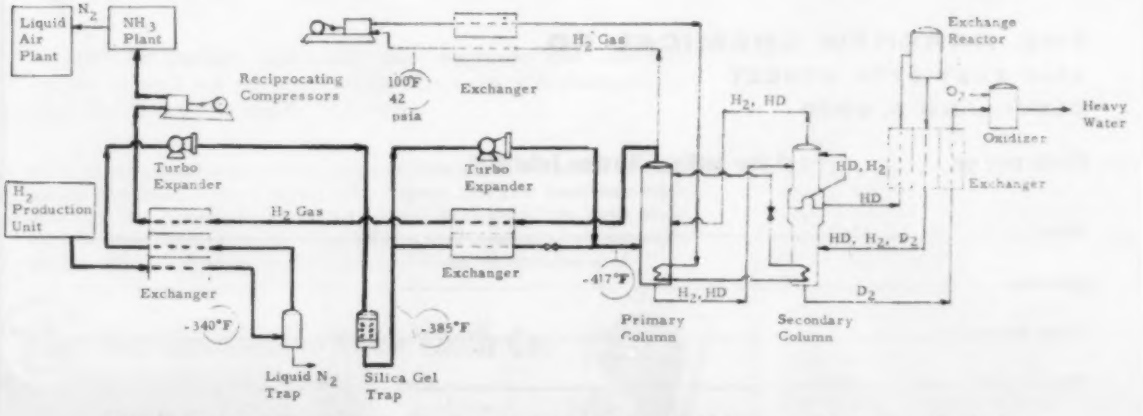
Purification of the gas is accomplished by scrubbing first with a monoethanolamine solution and then with a caustic solution to remove most of the CO_2. After cooling and drying, the last traces of impurities in the hydrogen gas are removed in a nitrogen wash tower.

The gas, essentially pure hydrogen with some nitrogen which was picked up in the wash tower and naturally occurring HD, is now chilled further in a heat exchanger. This removes part of the nitrogen as liquid. Further cooling is accomplished by an expansion engine. The last traces of nitrogen are removed in a silica-gel trap before the gas is throttled through a J-T valve to its saturation temperature and fed to the primary distillation tower.

Part of the overhead vapors from the primary tower after compression serves as the heating media for both the primary and secondary columns. The resulting condensed liquid is used as reflux for the primary tower. The enriched HD bottoms from the primary tower provide feed for the dual pressure secondary column. HD is concentrated in the bottoms of the upper half of this column and sent to an exchange reactor. Here equilibriation of the reaction $2HD \rightleftharpoons H_2 + D_2$ occurs. The products are fed to the lower portion of the secondary column with D_2 being concentrated in the bottoms. Oxidation of the D_2 produces the heavy water.

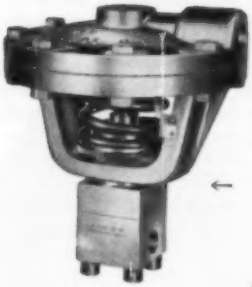
Deuterium-depleted hydrogen is

continued on page 132



Heavy water plant flow-sheet showing how plant can be integrated into conventional ammonia plant.

MINIATURIZATION From Pilot Plant to Process



"BANTAM" 500 SERIES VALVE

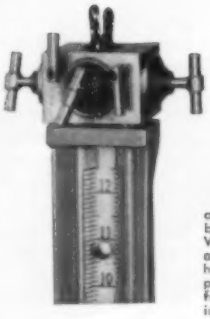
Throttling "Bantam" Diaphram Control Valves for all standard control valve uses, Cv of 0.6 and below, up to 1000 psi and 500°F, characterized, renewable trim, 316 stainless steel and *Teflon* only wetted surfaces, low in hysteresis size and weight, 2000 series "Bantam" Control Valves available for on-off service.

"MITE" 70

Pneumatic signal monitor. Embodies safety trip-out with manual or remote pneumatic reset. 250 PSI maximum pressure with trip adjustment for lock-up or vent from 1 to 100 PSI. Standard materials blue anodized aluminum. Other materials and models with integral two or three-way valves available.

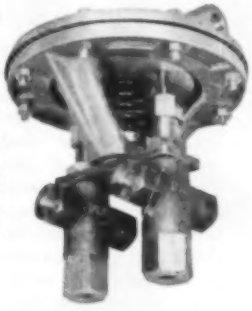
"DEMI" PACKLESS VALVE

For services when packing is a problem, manifolding of small valves in one unit at low cost. For services up to 750 psi and 500°F, screw, toggle, or diaphragm operated, the "DEMI" line is ideal for panel mounting up to five valves in one block.



"DEMI 54"

5 Valve Manifold for integral mounting on cleanout type Manometer. Packless design, 2 shut off valves, one bypass valve, 2 vent valves. Other 3 or 5 valve models available with or without special manometer mounting.



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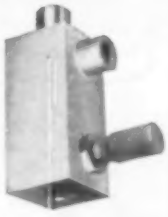
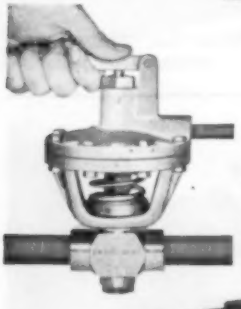
Two valves operated simultaneously by one operator. Valves may be globe or three-way and have a multitude of piping arrangements for mixing and routing applications.

CONSTANT VOLUME REGULATOR

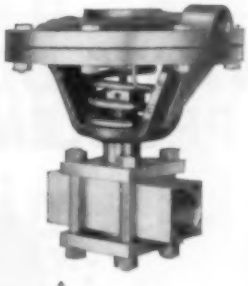
Fully automatic regulation provides constant volume output of gas or air regardless of fluctuating pressure drop. Capacity control by micrometer adjustment assures accuracy of desired output volume from 5.0 to 180 SCFH at pressure differentials from 1 to 25 PSI. Brass Body.





MANUAL RESET

Wherever control air on dangerout or toxic process flows must be blocked for safety, on air failure until manually reset, these valves insure against disaster. Standard sizes ¼" and ½" I.P.S.

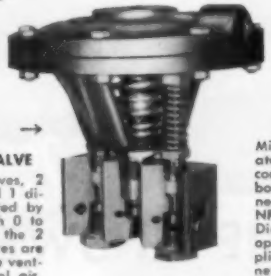


AIR OPERATED CONTROL VALVE

Miniature diaphragm operated control valve. Barstock construction with bolted bonnet and blindhead. Connections from ¼" to 1" NPT. Cv. from .001 to 10.0. Direct or reverse acting operators for control applications. Extension bonnets for extreme temperatures available.

THROTTLING CONTROL VALVES WITH TOP MOUNTED MOORE POSITIONER

Compact, accurate and rugged. Light weight. Sizes from ¼" to 1" NPT. Flanged connections available. Barstock bolted bonnet, blindhead and body. Cv. from .001 to 10.0 with pressures to 1000 PSI.

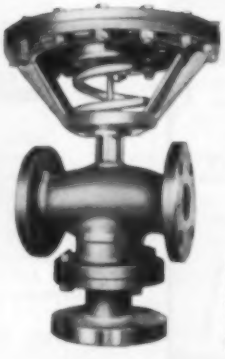


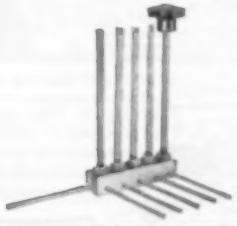
BLOCK VENT VALVE

3 balanced valves, 2 reverse acting and 1 direct acting, actuated by one operator. With 0 to 3 psi control air, the 2 reverse acting valves are closed, center valve vented. At 6 psi control air, all valves closed. At 12 to 15 psi, the 2 reverse acting valves are open and the vent valve is closed, allowing free flow through body. Design pressure 1000 psi. *Teflon*, Chevron packing. *Teflon* seating for tight shut off.

DIAPHRAGM OPERATED 3-WAY CONTROL VALVE

Aluminum diaphragm operator, stainless steel body and trim, *Teflon* packing with *Teflon* seating for tight shut off. Available up to 2", flanged or screwed.





MINIMUM VOLUME MANIFOLD

A compact manifold consisting of five packless valves having .0006 cubic inches volumetric displacement. Can be cam actuated for programming applications. Soldered, welded, tubing or NPT connections with applicable materials of manufacture for high temperature and high pressure service.

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Write us for complete technical information, or for the address of our representative in your area.

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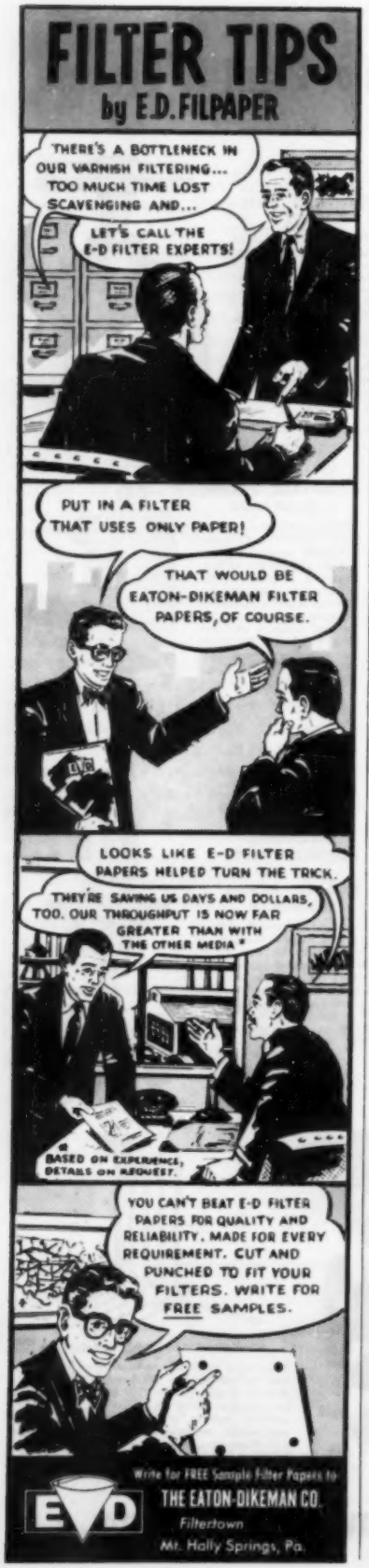
FILTER TIPS
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THERE'S A BOTTLENECK IN OUR VARNISH FILTERING... TOO MUCH TIME LOST SCAVENGING AND...
LET'S CALL THE E-D FILTER EXPERTS!
PUT IN A FILTER THAT USES ONLY PAPER!
THAT WOULD BE EATON-DIKEMAN FILTER PAPERS, OF COURSE.
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Filtertown
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Heavy water

continued from page 130

returned from the overhead of the primary column to the ammonia plant, recompressed, and mixed with the compressed nitrogen. The combination of H_2 and N_2 in the correct 3:1 ratio receives further recompression before passing into the ammonia converter. Here over an iron catalyst, hydrogen and nitrogen combine to form ammonia. The ammonia is condensed and sent to storage. Unconverted gas is recirculated back to the ammonia converter for additional processing. A more detailed description of this ammonia synthesis is given elsewhere (*3*).

Coke oven gas and air

Still another new hydrogen source for ammonia synthesis has been outlined recently (*4*). Here low-temperature technology has made possible the first U.S. plant designed entirely around the use of coke-oven gas and air as the raw materials. The logical spot to add the heavy-water plant in this process would be directly after the liquid nitrogen scrubbing column in the nitrogen wash unit. This is again dictated by the favorable temperature conditions existing at this point.

Naturally other modified synthetic ammonia processes could be used in conjunction with a heavy-water plant. These two processes have, however, been chosen because of a recognizable reduction in the cost of the heavy water produced.

Regardless of the ammonia process used, it has been estimated that with 90% conversion of hydrogen to ammonia and 86% recovery of the deuterium from hydrogen it would be possible to produce 0.46 lb. of heavy water per ton of ammonia produced.

Costs for the heavy-water-plant addition to the ammonia synthesis plant are quite nebulous at this stage. Estimates of $11,000,000 total investment were made by Hydrocarbon Research, Inc., in 1951 for a plant to produce up to 40 tons of heavy water annually. The annual cost of operating the plant was estimated to be slightly in excess of $1,000,000. This might be $1,500,000 today. On this basis, the investment cost for a plant of this type if built today would be around $190/lb. of D_2O/yr., and the operating cost would be approximately $19/lb.

The conclusion that can be drawn

continued on page 134

WASTE DISPOSAL PROBLEMS?

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John Zink Waste Disposal Units are custom designed to your specifications, for your individual application. Any size or capacity can be furnished for use in reducing liquid and semi-liquid wastes, or obnoxious gases. Available as a complete unit or burners only. John Zink Waste Disposal Units have been field-proven in process service throughout the world.

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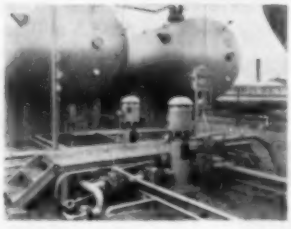
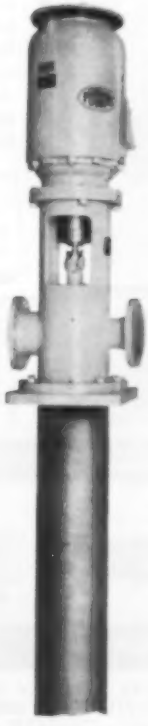
PEERLESS PUMPS





"Fill it up!" and nearly 60 million automobiles take an annual 56 billion gallon drink. Helping to "set 'em up again" for aircraft, automobiles, L-P gas and diesel engines, virtually every type transportation, is the Peerless Hydro-Line® vertical pump. Available in two basic types, process and transfer, the Peerless Hydro-Line is serving in the handling of hydrocarbons such as gasoline, butane, propane, hot oils, etc.; hot or cold water; mild acids, basic and salt solutions. This flexibility of application, plus its space-saving vertical design, its outstanding NPSH (net positive suction head) characteristics and its ready adaptability to future system requirements, has made the Peerless Hydro-Line truly one of America's most versatile pumps. For complete information on the Peerless Hydro-Line vertical pump line, write for Bulletin No. B-1700.

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PROCESS EQUIPMENT
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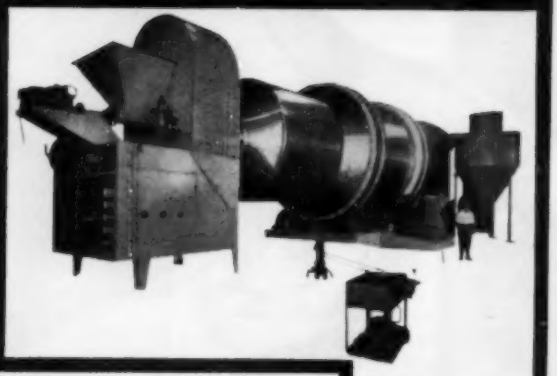
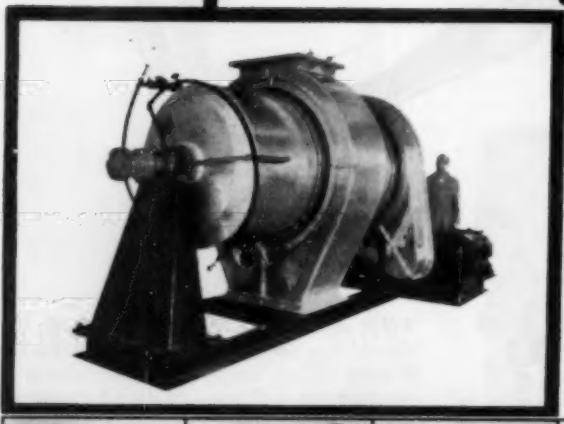
Renneburg low temperature, variable inclination, rubber-tired, steam-heated DehydrO-Mat Dryer for ammonium nitrates and other hard-to-dry chemicals requiring long hold-up times.





Renneburg stainless steel rotating steam-jacketed Batch Dryer with explosion-proof aluminum jacket for Rocket Fuel Program.

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Heavy water

continued from page 132

from these figures is that unless at least several tons per year of heavy water are to be produced for a period of ten years or more it would not pay to build and operate a heavy-water plant at the prevailing U.S. selling price. The cost of producing on a small scale, or for a short time, is naturally much higher than for the long-term, large-scale production.

Where ammonia synthesis gas or water gas containing a minimum of at least one million cubic feet of hydrogen per hour is being used and processed, the hydrogen-distillation process for producing by-product heavy water has promise of lower costs than any other process considered to date. This is particularly true of gas for ammonia synthesis purified in the manner described—by washing out the impurities with liquid nitrogen.

LITERATURE CITED

1. Benedict, Manson "Survey of Heavy Water Production Processes." Proc. International Conference on the Peaceful Uses of Atomic Energy, 8, p. 337 (1956)
2. Hydrocarbon Research, Inc., "Low Temperature Heavy Water Plant" Report NYO—889 to U.S.A.E.C. (March 15, 1951).
3. *Chem. Eng.*, p. 222 (May, 1954).
4. *Chem. Eng.*, p. 400 (June, 1956).

Advanced techniques in the use of instrumentation in liquid pipeline transportation will be featured in an all-day session of the Annual Instrument-Automation Conference and Exhibit in Philadelphia, September 15-18. Full program details available from Instrument Society of America, 313 Sixth Ave., Pittsburgh, Pa. #

Textile-finishing compounds will be turned out by Seydel-Woolley & Co. in a new plant to be erected at Atlanta, Georgia. Design and construction will be by Blaw-Knox, will feature use of a 1,500 gallon, gas-fired, radiant-heated kettle equipped with completely automatic temperature control. #

A $3.5 million contract for design, engineering, and construction of a citric acid plant has been awarded to Badger Manufacturing by Miles Laboratories, Elkhart, Indiana. Completion is scheduled for mid-1959. #

Use of tonnage oxygen in steel making continues to expand, with two new installations announced by Air Products. One, to go on stream this fall at the Clairton Works of U.S. Steel, will produce 22 million cu. ft/month; the second, at the Granite City Steel Co. in Granite City, Ill. (near St. Louis), will have a capacity of about 60 million cu. ft./month. #

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ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

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WORLD'S FIRST COMMERCIAL SCALE SHELL PROCESS ETHYLENE OXIDE PLANT ON STREAM

Plant for Wyandotte Chemicals Corporation Reaches Capacity Within 2 Weeks of Start-up

The first commercial scale plant to use the Shell Development Company's direct oxidation process for making ethylene oxide is on stream for Wyandotte Chemicals Corporation at Geismar, La.

This is the first of three ethylene oxide plants being designed, engineered and constructed by The Lummus Company, each with an annual capacity equivalent to 60,000,000 lbs. of ethylene oxide.

Most of Wyandotte's oxide will be converted by thermal hydration to ethylene glycol for industrial and antifreeze uses.

The process units at Wyandotte consist of an ethylene oxide reaction section, an ethylene oxide purification section, an ethylene glycol section and an oxygen generation section.

Non-process units provided by Lummus include: tankage and yard transfer facilities, cooling and fire-water system, an administration building, change and gate house, warehouse and shop building, and a garage and firehouse.

In the Shell Process for making ethylene oxide, ethylene is reacted with oxygen over a silver catalyst in a fixed bed reactor.

The Shell innovations which have been thoroughly tested in pilot plants offer several noteworthy advantages. Among these are high yields and virtual elimination of the waste disposal problems encountered in the chlorohydrin process. The plant uses oxygen, which requires less capital investment than the use of air.

The other two plants currently under construction by Lummus are for Calcasieu Chemical Corporation, at Lake Charles, La. and for Petrochemicals Ltd., one of the Royal Dutch Shell group of companies, at Partington, England. Both are scheduled to go on stream later this year.

Lummus is proud of the initial performance at Wyandotte in placing the Shell Process into full scale application. These ethylene oxide plants are 3 more of the over 800 plants designed, engineered and constructed by The Lummus Company throughout the world, in the last 50 years, for the process industries. Lummus is ready to place this experience at your disposal.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y., Houston, Chicago, Washington, D. C., Montreal, London, Paris, The Hague, Caracas, Maracaibo. *Engineering Development Center:* Newark, New Jersey.

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future meetings

1958—A.I.Ch.E.

• Cincinnati, Ohio, December 7-10, 1958. Netherland Plaza Hotel. **A.I.Ch.E. Annual Meeting.** (for further information see page 100.)

1958—A.I.Ch.E. Local Section One-Day

• Galveston, Texas, Oct. 3, Moody Center Building. **13th Annual Technical Meeting, South Texas Sect. A.I.Ch.E.** Gen. Chmn.: K. S. McMahon, Hedrick Engg. Corp. Panel—**Management and an Individual's Education, Advancement, and Future**—Moderator, F. M. Tiller. Panelists: R. W. Ericsson, Texas Butadiene & Chem. Corp.; E. E. Ludwig, Dow; B. H. Sloane, Alcoa, and H. G. Osborne, Continental; Symposium — **Modern Computation Methods**—W. B. Howard, Monsanto. Papers: **Computers and the Engineer**—J. C. Kaskie, Monsanto; **Introduction of the Analog Computer**—E. A. Clarke, Humble Oil; **Digital Computer Calculations in Distillation**—S. H. Davis, Rice Inst.; **Effect of Vapor-Liquid Equilibria Values upon Distillation Calculations**—J. S. Bonner, Bonner & Moore and E. L. Ekholm, Pace Co. Symposium—**Use of Statistics in Research and Production**—J. G. McQuarrie, Monsanto. Papers: **Using Statistical Methods to Define the Problem**—T. L. Rapp, UCC; **Power of Statistically Designed Experiments and Results to be Expected**—R. A. Stewart, Shell; **Efficient and Economical Means of Determining Optimum Conditions Through Experimentation**—H. F. Smith, DuPont; **Determining Optimum Conditions—Through Plant Operations**—P. W. Tidwell, Monsanto. General Session—R. D. Hornbeck, Monsanto. Papers: **An Improved Absorption Refrigeration Cycle**—E. P. Whitlow & J. Swearington, Southwest Res. Inst.; **Improved Process for Fuel Products Deasphalting**—N. P. Peet, J. P. Peet, & J. E. Lawson, Humble Oil; **Formation of Gas Bubbles at Submerged Orifices**—W. B. Hayes, III & C. D. Holland, Texas A&M; **The Solubility of Inert Gases in Water**—D. M. Himmelblau, Univ. of Texas. Group Discussion—**Professionalism—What Does it Mean?**—J. J. McKetta, Univ. of Texas; **Present Trends and Planning for the Future in Engineering Curricula**—W. W. Hagerty, Univ. of Texas.

• New York, N.Y. Oct. 23, 1958. Hotel Statler. **All-Day Symposium of New York Sect. A.I.Ch.E.** Gen. Chmn.: T. B. Richey, N. I. Malmstrom & Co., Brooklyn. **Cost Engineering**—C. H. Chilton. Papers: **Selecting the Estimating Method**—C. E. Zearfoss, Hydrocarbon Rsch., Inc.; **Project Cost Control**—L. W. Blazey, Merck; **Business and Building in the Years Ahead**—O. C. Smith, F. W. Dodge Corp. **Foams & Froths**—E. L. Gaden, Columbia U. Papers: **Practical Industrial Foam Control**—E. G. Tajowski, G.E.; **Foam Separation**—V. Kevorkian, Esso.; **Removal of Metals from Solution by Foam Separation**—R. W. Schnepf, Radiation Applic., Inc. **Petroleum Chemicals**—H. I. Wolff, Shell. Papers: **Electrostatic Considerations in the Organic Chemicals Industry**—D. I. Saletan, Shell; **Perchloroethylene**—J. W. Colton, Scientific Design; **High-Purity Aromatics from Ethylene Manufacture**—S. W. Swanson, Universal Oil. **Trade Secrets & Patents**—T. G. Gillespie, Scientific Design. Papers: **Patents**—T. G. Gillespie; **Infringement Suits**—M. Cohen, Hubbell & Cohen; **Trade Secrets**—J. Kelton, Leavenworth, Kelton & Taggart.

1958 Non-A.I.Ch.E.

• Ottawa Canada, Sept. 28-Oct. 2, 1958. Chateau Laurier. **114th Meeting, The Electrochemical Society.**

• Buffalo, N. Y. Oct. 2-3, 1958. Statler-Hilton Hotel. **2nd Annual Chemical Div. Conf., American Society for Quality Control.**

• Springfield, Mass. Oct. 20-22, 1958. Sheraton-Kimball Hotel. **13th Plastics-Paper Conf. of TAPPI.** To include fiber-plastics combinations.

• New Orleans, La. Oct. 20-24, 1958 and Los Angeles, Cal. Nov. 17-21, 1958. **Regional Meetings of National Association of Corrosion Engineers.** To include papers on corrosion in chemical & food processing, and petroleum industries.

• San Francisco, Cal. Oct. 22-24, 1958. Francis Drake Hotel. Amer. Vacuum Soc. **Vacuum Techniques—Theory, Applications, Processes, and Equipments.**

1959—MEETINGS—A.I.Ch.E.

• Atlantic City, N. J. March 15-18, 1959. **A.I.Ch.E. National Meeting.** Chalfonte Haddon

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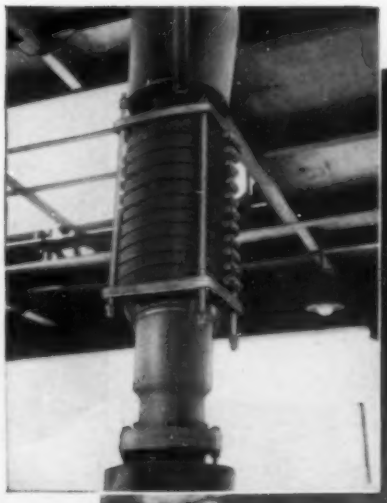
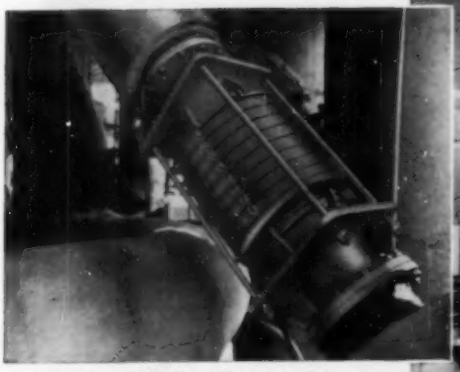
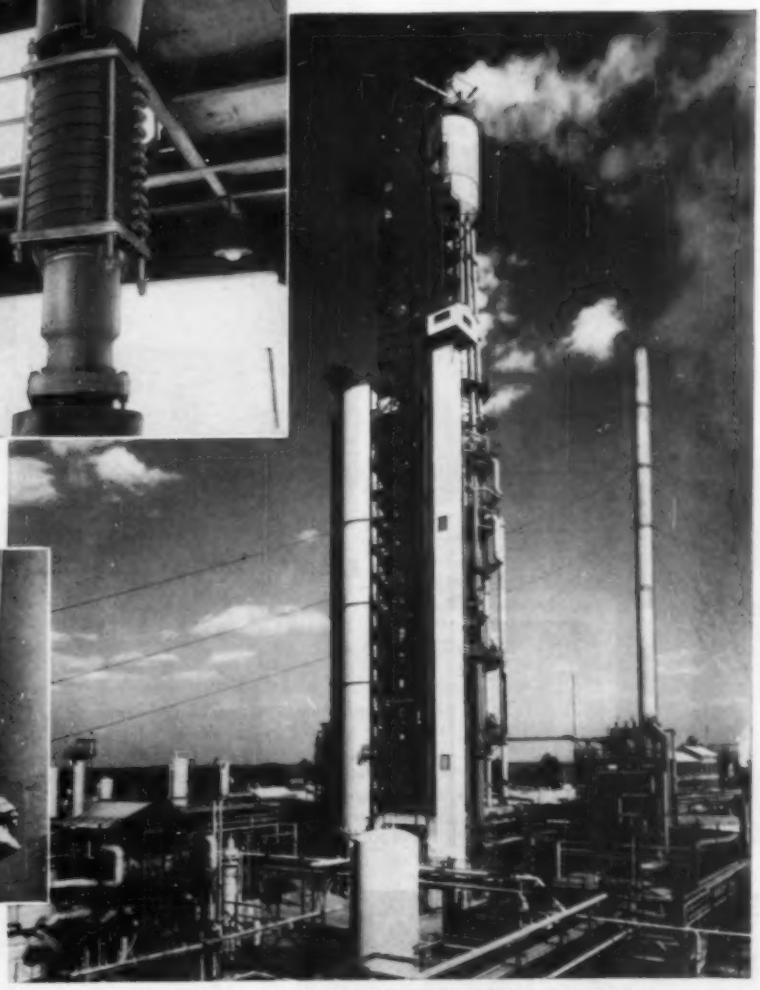


ADSCO Corruflex Expansion Joint with #316 stainless steel element. From the position of the tie-rods, note the pipe movement the joint is absorbing.



In this section of the Houdriflow unit, there are 12 ADSCO Corruflex Expansion Joints with #316 stainless steel elements. Temperature here is 1100°F.



Houdriflow Catalytic Cracking Unit, Marcus Hook Refinery, Sun Oil Co.

LET THE PIPES SQUIRM . . .

ADSCO

EXPANSION JOINTS ARE ON THE JOB!

Here, at the Marcus Hook Refinery of Sun Oil Co., temperatures run high. The piping naturally moves around a bit. But Sun engineers don't worry because they installed 62 Adsco Corruflex Expansion Joints to take the movement. Lateral offset, angular rotation, off-tackle slants... name it and Adsco Expansion Joints can absorb it. If you expect your pipes will get frisky, call our nearest sales-engineer, *or contact Adsco Division, Yuba Consolidated Industries, Inc., 20 Milburn St., Buffalo 12, N. Y.*

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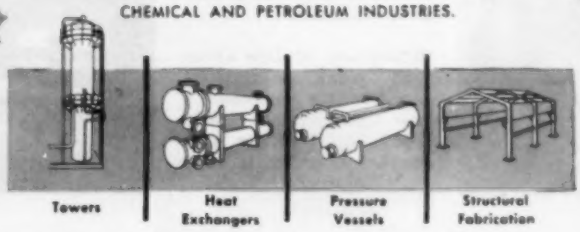

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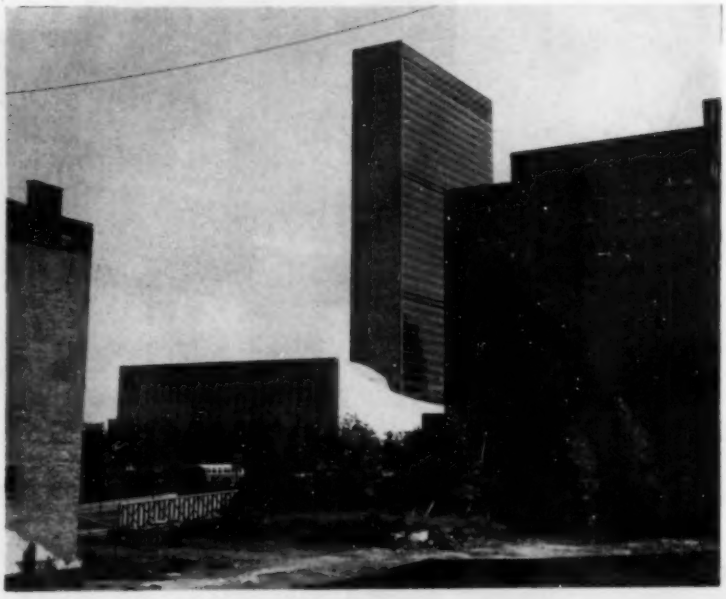
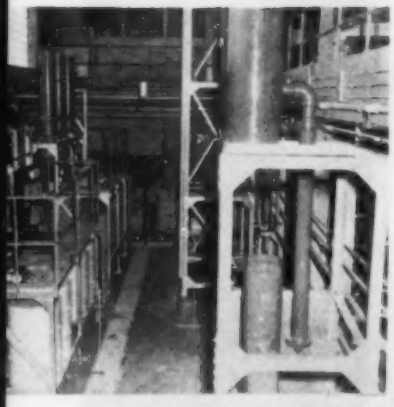
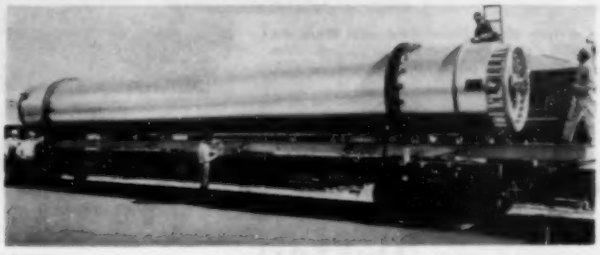
United Engineering Center will be here

Site of the new home of the engineering professions. View is looking southeast across the lot where the building will be toward the United Nations buildings. Drive for the required funds to begin work on the long-awaited United Engineering Center is in full swing with each society striving for full membership participation in the fund campaign.

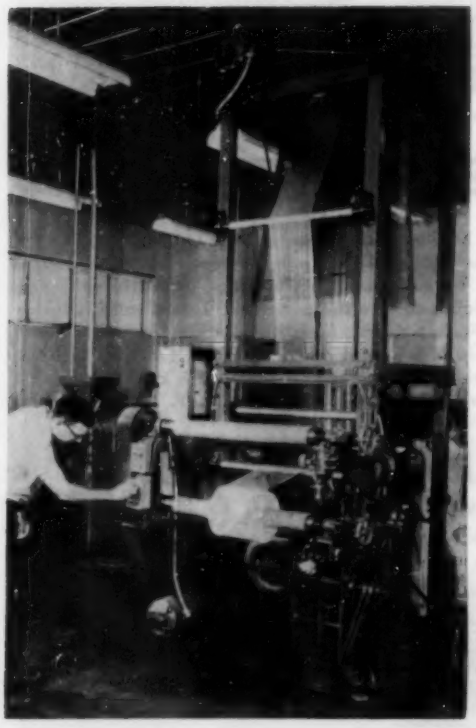




New chemistry-chemical engineering building at South Dakota School of Mines and Technology (right) was dedicated recently by T. H. Chilton. Equipment in the chemical engineering laboratory (left) includes a liquid-liquid extractor unit and a vacuum evaporator.



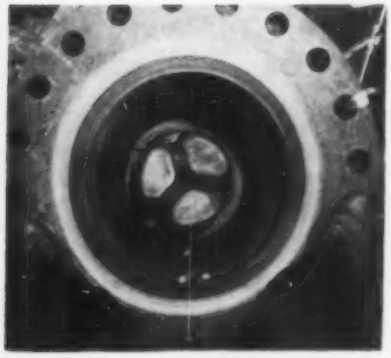
One of two all-welded aluminum steam tube dryers ready for shipment to W. R. Grace's new low pressure polyethylene plant built at Baton Rouge, La., by Fluor Corp.



(Left) A super-thin 2/10ths mil polyethylene film has been produced on this full-scale film extruder at U.S. Industrial Chemical's Tuscola, Ill., laboratory.

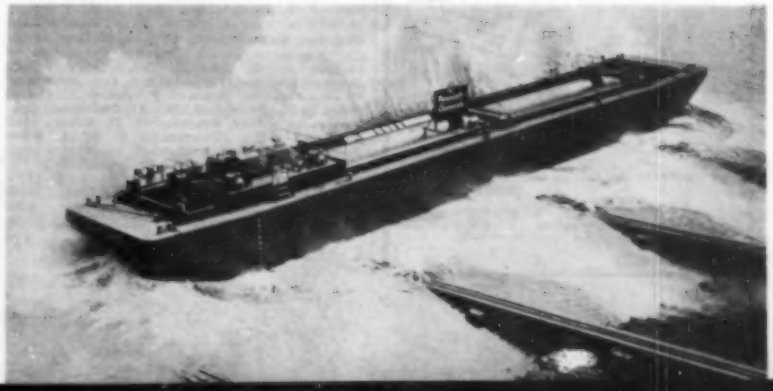
Slitting unit at Dow's Midland plant is rerolling Trycite, the company's new polystyrene packaging film which is said to be priced lower than most competitive films.

cep camera



A powerful stream of dissociated, ultra-hot air is discharged as a plasma stream (left) from General Electric's large, new, plasma-jet generator which can produce temperatures over twice the surface temperature of the sun. The three electrodes (above) are variously shaped to help provide differences in plasma flow, and are shorted across to begin the run. Air is forced tangentially along the container wall from openings at the base of the electrodes. The rushing, sweeping air provides cooling effects, and the air itself is basically the raw material of the plasma.

The first shipload of butadiene ever to be moved across the ocean is aboard the Gasbras Sul. Left to right are: J. M. Hause, terminal superintendent of Texas Butadiene and Chemical which furnished the butadiene, Captain Sigmund Andreassen of the Gasbras Sul, and Hill Westmoreland, Texas Butadiene plant manager.



The second of two tank barges built for Pennsalt is launched at Dravo Corp.'s Neville Island shipyards near Pittsburgh. The barge contains two 60,000-gal. lined and Foamglas insulated tanks, will be used to carrry caustic soda and caustic potash.

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future meetings

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Hall Hotel. Gen. Chmn.: J. D. Stett, Dept. Mech. Eng., Rutgers Univ., New Brunswick, N. J. Tech. Prog. Chmn.: N. Morash, Natl. Lead Co., P.O. Box 58, So. Amboy, N. J. **Recent Advances in Plastic Materials of Construction**—M. F. Gigliotti, Monsanto Chem. Co., Plastic Div., Springfield, Mass. **Business & Technology**—J. Happel, NYU. **Theoretical and Laboratory Work on Liquid-liquid Extraction**—R. E. Treybal, NYU, Univ. Heights 53, N. Y. **Laboratory and Pilot Plant Techniques**—G. W. Blum, Goodyear Tire & Rubber Co., Akron, Ohio. **Missiles, Rockets & Satellites**—O. C. Szego, Gen. Elect., Aircraft & Gas Turbine Div., Cinn. 15, Ohio. **General Papers** (2 sessions). J. Joffe, Newark Coll. of Eng., 367 High St., Newark 2, N. J. and E. C. Johnson, Dept. of Chem. Eng., Princeton U., Princeton, N. J. **Computer Control of Processing Units**—J. M. Mosley, Johns Hopkins Hospital, Baltimore 5, Md. **Startup of New Chemical Plants**—M. L. Nadler, DuPont, Penns Grove, N. J. **Care and Feeding of Executives**—J. S. Wilson, Heidrick & Struggles, 20 No. Wacker Dr., Chicago 16, Ill. **Mechanics of Fluid-Particle Systems**—S. K. Friedlander, Johns Hopkins Univ., Balt., Md. **Process Data & Design Methods for Nuclear Fuel Recovery**—C. E. Stevenson, Rsch. Dir., P.O. Box 1259, Idaho Falls, Idaho. **Thermodynamics of Phase Equilibria**—E. M. Amick, Jr., Chem. Eng. Dept., Columbia U., New York 27, N. Y. **Market Research & the Chemical Engineer**—William Copulsky and R. Cziner, Grace R&D Co., 3 Hanover Sq., New York 4, N. Y. **Thermal Stability of Jet and Rocket Fuels**—C. J. Marsel, NYU, Univ. Heights, New York, N. Y. **Wood as a Chemical Raw Material**—E. G. Locke, U. S. Forest Prod. Lab., Madison, Wisc.

Deadline for papers: November 16, 1958.

• Cleveland, O. April 5-10, 1959. **Nuclear Congress. Co-sponsored by A.I.Ch.E. and others.** A.I.Ch.E representative: E. B. Gunyou, Mngr. Nuclear Pr. Koppers Co., Koppers Bldg., Pitts. 19, Pa.

• Kansas City, Missouri, May 17-20, 1959. Hotel Muehlebach. **A.I.Ch.E. National Meeting.** Gen. Chmn.: F. C. Fowler, Consulting Chem. Engr., 7515 Troost Ave., Kansas City, Mo. Tech. Prog. Chmn.: Fred Kurata, Chem. Eng. Dept., Univ. of Kansas, Lawrence, Kansas. **Reaction Kinetics**—R. R. White, Dept. of Chem. Eng., Univ. of Michigan, Ann Arbor, Mich. **How to Become a More Proficient Technical Engineer. Heavy Chemicals**—N. J. Ehlers, Columbia-Southern Chem. Corp., 1 Gateway Center, Pitts. 22, Pa. **Petrochemicals**—G. E. Montes, Nat'l. Petrochemical Corp., Tuscola, Ill. **International Licensing and Collaboration**—R. Landau, Scientific Design Co., 2 Park Ave., New York, N. Y. **General Papers** (2 sessions). J. O. Maloney, Univ. of Kansas, Lawrence, Kan. and Merk Hobson, Univ. of Nebraska, Lincoln, Nebr. **Non-Equilibrium Fluid Mechanics**—M. J. Rzasa, Cities Services Res. Lab., P. O. Box 402, Cranbury, N. J. **Role of Wetting and Capillarity in Fluid Displacement Processes**—C. S. Kuhn, Magnolia Petroleum Co., 907 Thomasson Dr., Dallas, Tex. **Thermodynamics of Jet & Rocket Propulsion**—O. C. Szego, Gen. Elect. Aircraft & Gas Turbine Div., Cinn. 15, Ohio. **Computers and Pipelines**—R. L. McIntire, The Datics Corp., 600 Camp Bowie Blvd., Fort Worth, Texas. **What's New in Liquid Metals Technology**—H. M. Rodekohr, Ethyl Corp., P. O. Box 341, Baton Rouge, La. **Ten Ways to Improve Technical Reports**—Robert Gunning, Blacklick, Ohio.

Deadline for papers: January 17, 1959.

• St Paul, Minn., Sept. 27-30, 1959. Hotel St. Paul. **A.I.Ch.E. National Meeting.** Gen. Chmn.: W. M. Podas, Asst. Rsch Dir., Economics Lab., Guardian Bldg., St. Paul, Minn. Tech. Prog. Chmn.: A. J. Madden, Jr., Univ. of Minn. **Mixing**—J. Y. Oldshue, Mixing Equip. Co., Inc. P. O. Box 1370, Rochester 3, N. Y. **Size Reduction**—E. L. Piret, Chem. Eng. Dept., Univ. of Minnesota, Minneapolis 14, Minn. **Missile Construction Materials**—B. M. Landis, Gen. Elect. Co., Cleveland 12, O. **Physical Properties of Liquids**—S. E. Isakoff, Dupont Co., Eng. Dept., Expr. Sta., Wilmington, Del. **Molecular Engineering**—M. Boudart, Princeton U., Chem. Eng. Lab., Princeton, N. J. **Chemical Economics as a Unit Process**—M. H. Baker, 1645 Hennepin Ave., Minneapolis 3, Minn. **More Research for Your Dollars**—T. S. Mertes, Sun Oil Co., 1608 Walnut St., Philadelphia 3, Pa.

• San Francisco, Calif., December 6-10, 1959. **A.I.Ch.E. Annual Meeting.** Gen. Chmn.: Mott Souders, Jr., Shell Development Co., 4560 Horton St., Emeryville 8, Calif. Tech. Prog.

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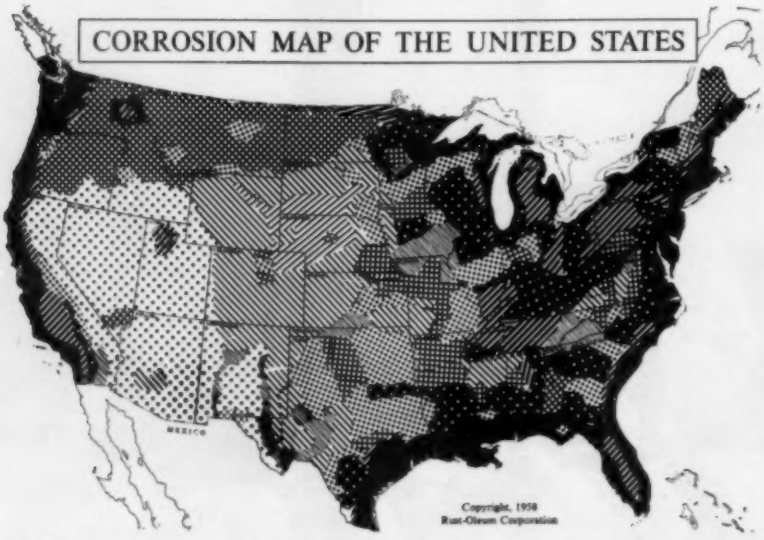

The map and figures show the number of years and months required to corrode an uncoated 28-gauge steel test panel to a severe degree in parts of the U.S.

U.S. Corrosion Pattern Established

Comparative corrosion rates published for all U.S. cities with over 10,000 population

It takes three years, the fastest rate in the country, for rust to corrode a standard, uncoated steel test panel, the size of an auto license plate, in four different cities — Buffalo and Rochester, N. Y.; Erie, Pa.; and Miami, Fla. Slowest rust rate, more than 15 years, is in Tucson, Ariz.; Roswell and Santa Fe, N.M. In all the nation's major industrial centers, the rust rate is under four years.

The Rust Index of the United States, just published by Rust-Oleum Corp. of Evanston, Ill., lists the 523 cities of the country with a population of more than 10,000 and the comparative rust rate for each city. The index was compiled in a 25-year research program in which dated, uncoated steel panels were left exposed at industrial sites throughout the country; the panels were of 28 gauge, low-carbon, cold-roll sheet steel.

Of the 523 cities listed, 221, or 42%, were indexed as Class I, meaning that test panels there rusted in less than four years. Class I includes every major industrial area, and most of the nation's secondary industrial centers. In Class II, where test panels rusted in from four to five years, are 95 cities. Taken together, the 316 cities in Classes I and II comprise 60% of the nation's cities with populations over 10,000.

Custom research facilities in vacuum metallurgy have been established by F. J. Stokes Corp., Philadelphia. Equipment available includes an induction-heated vacuum melting furnace with a crucible capacity of 17 pounds and capable of handling ingots up to 15 inches high by 10 inches in diameter. #

Chemistry of solid rocket propellant components and high-temperature inorganic polymers will be studied under an Air Force contract awarded to U.S. Borax Research Corp., Anaheim, Calif. Aimed at new materials to withstand temperatures of 1,000°F in missile and aircraft applications, the research program is expected to stress boron, nitrogen, aluminum. #

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future meetings

from page 140

Chmn.: C. R. Wilke, Div. of Chem. Eng., Univ. of Calif., Berkeley, Calif. **Process Dynamics**—E. F. Johnson, Dept. of Chem. Eng., Princeton Univ., N. J. **Operations Research**—R. R. Hughes, Shell Dev. Co., Emeryville,8, Cal. **Progress and Problems in Jet and Rocket Combinations**—C. J. Marsel, NYU, University Heights, New York 53, N. Y. **Secondary Oil Recovery Methods**—F. H. Poettman, Ohio Oil Co., Littleton, Colo. **New Oil Sources—Shale, Gilsonite, Tar Sands; Financing in the Chemical Industry; Raw Materials for the Chemical Industry; Turbulence and Turbulent Mixing; High Temperature: Thermodynamics, Reactions, Kinetics; Devices, and Materials; Electro-chemical Engineering-Process Design; Fundamental Aspects of Chemical Engineering in the Pulp and Paper Industry.**

Deadline for papers: August 6, 1959.

1960—MEETINGS—A.I.Ch.E.

• Atlanta, Ga. Feb. 21-24, 1960. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: Fred Bellinger, Ga. Inst. of Techn., 225 North Ave., N.W., Atlanta 13, Ga.
• Mexico City, Mexico, June 20-24, 1960. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: O. E. Montes, Nat'l Petrochemical Corp., P.O. Box 109, Tuscola, Ill.
• Tulsa, Okla., Sept. 4-7, 1960. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: K. H. Hachmuth, Phillips Petroleum Co., Bartlesville, Okla.
• Washington, D. C., Dec. 4-7, 1960. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: D. O. Myatt, Atlantic Research Corp., Alexandria, Va.

Unscheduled Symposia

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.
Chemical Engineering Process Dynamics as They Affect Automatic Control: David M. Boyd, 315 Ridge Ave., Clarendon Hills, Ill.
The Threatened Imbalance Between Chlorine and Alkali in American Chemical Industry: Zola G. Deutsch, Deutsch & Loonam, 70 E. 45th St., New York City 17.
Computers in Optimum Design of Process Equipment: Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.
Financing for the Chemical Industry: Bernard Stott, First National City Bank of New York City, New York, N. Y.
Chemical Engineers in Chemical Industry Management: T. P. Forbath, American Cyanamid Co., 488 Madison Ave., New York, N. Y.
Training on the Job for Industry: John Happel, Dept. of Chem. Eng., N. Y. University, University Heights, New York 53, N. Y.
Preparation of Catalytic Cracking Charge Stocks and Quality Criteria Therefor: Wheaton W. Kraft, Lummus Co., 385 Madison Ave., New York 17, N. Y.
Solar Energy Research: J. A. Duffie, Director of Solar Energy Laboratory, Univ. of Wisconsin, Madison, Wis.
Hydrometallurgy—Chemistry of Solvent Extraction: G. H. Beyer, Dept. of Chem. Eng., Univ. Mo., Columbia, Mo.
Mass Transfer Applications in Waste Treatment—W. W. Eckenfelder, Jr., Manhattan College, Riverdale, New York 71, N. Y.
In addition to the above, the following symposia in the management area are available from J. Happel, Dept. of Chem. Eng., New York Univ., University Heights, New York 53, N. Y.:
Market Research • Financing • Growth of the Chemical Industry • Distribution Between Dividends and Growth in Financing • Stock Market Analysis for Chemical Companies • International Growth • Filling Vacancies in Top Management • Duties of a Good Director • Where Chemical Engineers Go After Graduation • Long Term Planning.

Intensive research and development work on the organic compounds of boron and silicon will follow acquisition of Anderson Chemical Co., Weston, Mich., by Stauffer Chemical. Anderson Chemical has recently specialized in pharmaceutical intermediates and organo-metallic compounds.

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Polyurethane coatings show big promise for chemical industry use

While foams take the lion's share of the polyurethane market at present, the field of coatings may well be the major application of these materials in the chemical field due to their high chemical abrasion resistance.

Basically, a urethane polymer is the addition product of a polyisocyanate and a polyhydroxy material such as ethylene glycol. Polyurethanes may be classed as addition polymers similar to polyethylene and polyvinylchloride.

Major isocyanate raw material used today to make the urethanes is tolylene diisocyanate. Economically speaking, the most obvious characteristic of tolylene diisocyanate (TDI) is its excellent supply, estimated to be as high as 70 million pounds of TDI capacity. This is some three times consumption at present, with about 20 million pounds in use primarily for flexible foams.

To date, the field of flexible urethane foam has shown the greatest short-range potential for isocyanate consumption, and may end up with the major share of TDI. But the flexible foams are encountering stiffer competition these days especially from the new polyethers.

Rigid foams

The rigid urethane foams, while not currently enjoying the success of the flexible materials at least on a pound basis, nevertheless represent a very large factor in the overall urethane picture. They are currently the second largest consumer of isocyanates. The rigid foams are particularly adapted to foam-in-place techniques where their high-strength-to-weight ratio, excellent high-temperature resistance, and low moisture transmission characteristics are important in addition to the conforming properties.

Rigid urethane foams represent the second largest market for TDI in the present market. More isocyanate is required in proportion to the amount of polyol used, however, and fifty million pounds of rigid foam is approximately equivalent to 100 million pounds of flexible foams in TDI consumption.

Coatings

But it is in the field of coatings that the urethane materials hold the greatest promise for the chemical field as a market. Urethane coatings have good chemical abrasion resistance.

There are several remarkable examples of the durability of urethane anti-corrosion coatings which, seen in Germany by an American technical team, were recorded in the spring of 1955. These include the following:

1. Iron sulfide storage bins located above the roasting ovens in a sulfuric acid plant. These urethane coated bins are subjected to heat and fumes of SO_2 and SO_3. Although the coatings were then over a year old, they still exhibited excellent gloss and were protecting the metal from corrosion. The only evidences of corrosion were scorched areas just around the parts where the sulfide enters the oven.
2. Many items of equipment in a steel mill were protected with urethane coatings (220,000 pounds were required to complete the job). Although the coatings were already two to four years old, they were still in good condition. There was some surface chalking (loss of gloss) on upper surfaces, but the side and bottom areas were still glossy and free from corrosion. Equipment protected with urethane coatings included a blast furnace shell, gas scrubbers, a gas holder 120 feet in diameter and 270 feet high, treating furnaces and structural steel in a forge shop.

The forge shop was especially interesting in that part of it was painted with an alkyd. Whereas this had deteriorated, roughened, and become grimy, the urethane coated sections were still relatively clean. The smoothness and lack of porosity of the urethane coatings is another of their strong points.

3. A carbide stack on which the five year old urethane coating was still intact. Gasses passing through the stack were at a temperature of around 200°C.
4. Two rubber accelerator plants, one 2½ years old, the other eight year old, were observed. Here, the urethane coatings were successfully withstanding the action of acid, amine, and H_2S vapors. The corrosion engineer at these plants stated that other paints had not lasted two heavy-use years in this atmosphere.
5. The holds of several oil tankers had been protected with urethane coatings. These tankers alternately carry sour crudes and salt water ballast and the urethanes were withstanding these conditions.

Of interest were some of the *new uses found for urethane coatings in Europe*. Among these were:

1. Steel storage tanks for the storage of gasoline by a European army. The coating system consisted of sandblasted metal, wash primer, zinc chromate urethane primer, and at least three coats of a urethane formulation heavily pigmented with red iron oxide. All these formulations were air dried.
2. Steel storage tanks for edibles such as fruit juices, syrups, and wine. Where there is urethane coating, it is preferred to gloss because it is less brittle, easier to repair in the field, and is easier to clean.
3. Fifteen to twenty-gallon steel shipping containers were lined with urethane coating by twice slushing and allowing the excess coating to dry out. Most of the solvent was evaporated by blowing air through the drum, and they were then allowed to age for 8 to 14 days at room temperature. When used for food products, the drums were first rinsed out with hot water to remove solvent residues. These containers are used to ship 40% formaldehyde, beer, mineral spirits, oils and vegetable oils. Some 150,000 drums for beer have been manufactured by one company using a red iron oxide pigmented formula.
4. Many food processing plants paint their filling and packaging equipment with urethane coatings since they are so easily kept clean. These include plants that handle butter, margarine, lard, fruit juices, etc.

Urethane coatings have also demonstrated their adaptability to the coating of concrete, where they offer outstanding abrasion resistance combined with excellent chemical resistance.

Urethane coatings quickly develop a high order of film hardness. The

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Condensed from a paper presented by Roger Jennings, Polytron Corp., at a meeting of the Northern California Section of A.I.Ch.E.

hardness ultimately achieved is dependent upon the type of raw materials employed in the formulation. Coatings based on highly branched polyesters, for instance, are generally harder than those based on linear polyesters. Taber abrasion tests have shown urethane coatings to be far superior to conventional proprietary coatings. Urethane coatings show a Taber Wear Index Value of less than 60 where chlorinated rubber proprietary coatings show values in the neighborhood of 220 and epoxy coatings in the range of 190. Taber Wear Index equals milligrams loss in weight of samples times 1000 divided by the number of cycles. The higher the wear index value, the greater the amount of wear.

Two families

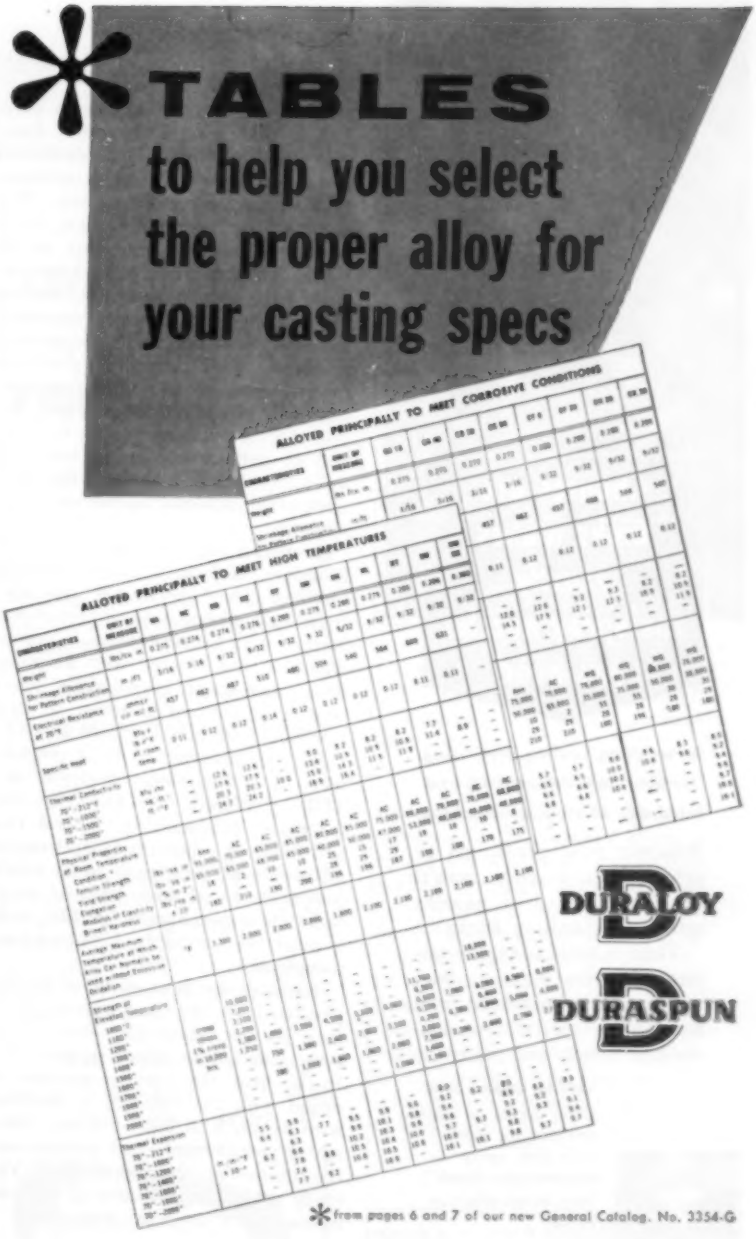
Urethane coatings belong to two fundamentally different families, but the resulting coatings are almost identical in physical properties. Coatings may be prepared by reacting TDI with castor oil and dissolving the prepolymer obtained in a suitable solvent. Before application, a catalyst is added to the solution, and the urethane film then reacts with itself and the moisture in the air to form a hard thermosetting surface coating. In the other system, a solvent solution of an isocyanate and a solvent solution of a polyester are mixed together just prior to application, moisture in the air being a relatively minor factor in the curing of the coating. Final physical properties to some degree determine the type of coating applied, however, personal prejudice on the part of the raw material supplier usually prevails. Baked coatings usually furnish better film properties than those which are air-dried.

The magnet-wire market is dominated by a 1-component system composed of a solvent solution of a polyester containing the proper amount of an isocyanate adduct, whose active isocyanate groups are "blocked" by an addition produce, usually phenol. The interesting thing about phenol-blocked isocyanates is that they liberate phenol and become active at temperatures in excess of 150°C. These one-component coatings, of course, must be baked and free phenol is always around in vapor phases.

Urethane rubber

Elastomers represent one of the most interesting of the urethane fields. The potentials for cheap urethane rubber are almost fantastic—tires that outlast the life of the car, etc. While urethane elastomers do exhibit some

continued on page 146



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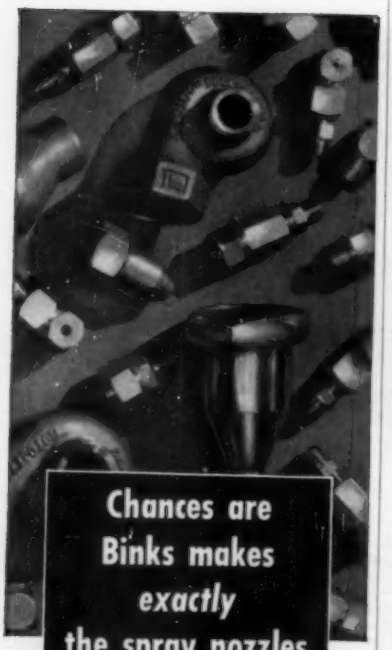

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Polyurethanes

from page 145

startling characteristics, such as abrasion resistance as much as five times that of natural rubber, and coefficients of friction just over unity, a combination of factors will prevent their adoption for commercial use for a number of years. Problems to be overcome in the rubber industry include high cost, difficulty in bonding urethane treads to heavy carcasses, molding problems and processing problems with sensitive elastomer raw materials. While foam consumption will ultimately drive down the cost of TDI and consequently the base cost of urethane elastomers, time and research will have to relieve the other associated problems of the elastomer industry.

Urethane elastomers are essentially flexible urethane foams without bubbles. They are usually produced from polyethers via a prepolymer method with excess isocyanate groups which is then reacted with an anhydrous, non-acidic cross-linking agent to give the finished elastomer. Typical materials currently available are Adiprene L, purported to be a prepolymer of 1,4-butylenepolyglycol and TDI, produced by DuPont; and Genthane, produced by General Tire and Rubber Corporation. Genthane, in all likelihood, judging from its brittle temperature and other physical properties, is a prepolymer of TDI with a polyether, probably 1, 4-butylenepolyglycol.

Probably the most exotic of the applications for urethane elastomers is their use as binder-fuel elements in composite solid rocket propellantry. In this field, the liquid prepolymer is mixed with the oxidizer, in loadings with as much as 90% oxidizer (usually a perchlorate), and poured into the combustion chamber to cure. Virtually every manufacturer of reaction motors has a urethane propellant.

Market development quantities of a new polycarbonate resin (Lexan) will be turned out at a new semi-works plant of General Electric at Pittsfield, Mass. #

Jefferson Lake Sulphur and Duval Sulphur and Potash have joined the Sulphur Export Corp. which now handles export sales for all U.S. producers of Frasch process sulfur. #

Menthane diamine (1,8-diamino-p-menthane) is now available on a commercial scale from Rohm & Haas. The material has proved interesting as a curing agent for epoxy resins. #

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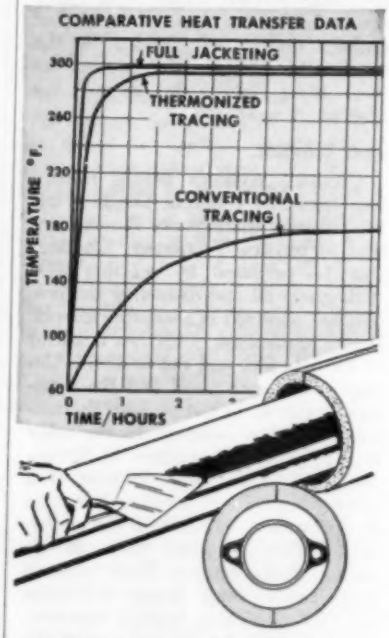

Thermon is a non-metallic plastic compound with highly efficient heat transfer properties, and is easily applied over either steam traced or electrical resistance systems . . . working equally well for either heating or cooling processes.

Thermonizing has excellent heat transfer characteristics (see curves), exceeding steam traced equipment approximately 1100%, and closely approaching jacketing equipment. Thermon can be used almost without exception in place of expensive jacketing (and in many applications where jacketing is impossible), with savings up to 90%.

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Active first half of the year for local sections

April saw president George Holbrook speaking before the **Maryland Section** *(Philip Messina)* where he dwelt on the increasing degree of cooperation between A.I.Ch.E. and its sister engineering societies. His talk served as introduction to the main speaker of the evening, M. Fenske of Penn State, who detailed the use of liquid ammonia in the extraction of petroleum components. Fenske went on to discuss modern techniques for improving the phase diagram in extraction processes, and solvent recovery systems.

"The automobile tire of tomorrow will be fabricated from predesigned synthetic rubbers. Each part of the tire—tread, sidewall, bead—will be made from the synthetic that best fits the need," prophesized William J. Sparks of Esso Research and Engineering, coinventor of butyl, addressing a joint February meeting of the ACS and the **South Texas Section, A.I.Ch.E.** *(E. W. Bowerman)*. Five years of research and development work, involving cooperation with all the major tire companies, continued Sparks, have answered in the affirmative the question whether we can build a good butyl tire. Tests on the new tire, already on sale semicommercially in the U.S., show 50% greater mileage than the best conventional tires, even at heavy overloads, he concluded.

Students of chemical engineering were guests at the January meeting of the **Ohio Valley Section** *(Gene Claybaugh)*; this innovation is part of an original program started three years ago as a joint project of the **Ohio Valley Section** and the University of Cincinnati. Object of the program—to give student engineers an opportunity to talk shop with graduate engineers who are actually working in industry. (It will be surprising if this idea is not picked up on the wing by other local sections.) Feature of the system is the practice of allowing plenty of time for informal discussions before and after the main session. Themes at this January meeting ranged from equipment design and manufacture, through research and development, process design and engineering, and production to sales and technical service. Speakers were all members of the local section. The

continued on page 148

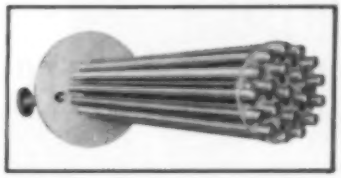
Fansteel

Corrosionomics

REGISTERED U. S. PATENT OFFICE

A JOURNAL OF USEFUL INFORMATION FOR THE SOLUTION OF CORROSION PROBLEMS

TANTALUM BAYONET HEATERS CUT ACID PROCESSING COSTS



Fansteel tantalum bayonet heaters come in a wide variety of sizes and shapes to fit the most critical need.

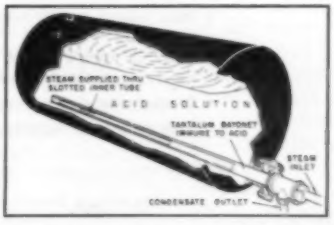
Tantalum bayonet heaters are the most economical heating units obtainable for extremely corrosive acid solutions (except hydrofluoric and fuming sulfuric). This can be proved on a cost reduction basis if all the factors of highly corrosive service are carefully considered.

Acid Proof—Long Life

Fansteel tantalum bayonet heaters are ideally suited to acid processing requirements for several reasons. First, the pure metal is not subject to thermal shock. It is acidproof, not just acid-resistant—which makes product contamination impossible. Fansteel tantalum also has high tensile strength, compressibility, impact strength and ductility. Since no corrosion allowance need be made, only the thickness required for structural strength need be used.

High Processing Rates

Acid processing rates are very high with Fansteel tantalum heaters. The special design permits rapid removal of condensate on the steam side, promotes high velocities of both steam and condensate, and keeps the condensate film at minimum thickness. The heaters are never flooded and air can be discharged readily with the condensate. Added to this is tantalum's high rate of heat transfer which further speeds processing. Overall coefficients of 500 to 1200 are commonly obtained.



For vessels with side or bottom openings, the bayonet heater is an effective unit (single or multiple tube). Steam enters through the inner steel pipe, escapes through slots near the end and heats the tantalum tube.

Overall Economy

These characteristics combine to make tantalum the ideal material for use in critical pieces of equipment such as heaters. The initial cost is more than justified by long, trouble-free service, simplicity of design made possible in associated equipment, and even upgrading equipment with heaters made from other materials. Heating capacities and standard sizes of Fansteel single-tube, bayonet heaters are shown in our Bulletin 3.506. They are also listed in the Chemical Engineering Catalog, page 750.

Free Tantalum Test Kit

A corrosion test kit, available without charge to research technicians, if requested on your letterhead; contains both tantalum sheet and wire.

Free Technical Information

The above condensation is typical of the articles which appear in CORROSIONOMICS, a Fansteel publication. Mail us your name for inclusion on our free mailing list.

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Full-scale geometric, kinematic, and dynamic similarities of Newtonian and non-Newtonian fluids are duplicated in Model ELB kit pilot plant and bench scale-up tests.

Contained in a sturdy, portable case, Model ELB features a constant speed ¼ hp. motor with a micrometer controlled variable speed transmission. Linear dial-speed relationship gives 0 to 1100 rpm, with low speed torque multiplication. Also included are 22 calibrated impellers, 3 shafts, and universal mounting.

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from page 147

Ohio Valley section invites correspondence from other sections interested in initiating similar programs.

The possible effect on human beings of the materials being handled in any chemical processing operation should be the constant preoccupation of every chemical engineer involved in any phase of the work, emphasized David W. Fassett, director, Laboratory of Industrial Medicine, Eastman Kodak, speaking to the members of the **Rochester, N.Y. Section** *(Frank Wells)*, assembled for their March meeting. Over the past thirty or forty years, a vast amount of work has been done to determine the physiologic effects of industrial chemicals. The important thing, brought out Fassett, is to apply this theoretical knowledge to the devising of proper precautionary measures for maximum control of the hazards involved.

Biological warfare

"There is no proof that biological warfare was used in World War II," said Glenwood B. Achorn, Jr., director of biological operations at the Pine Bluff, Ark., Arsenal. Speaking before the October, 1957, meeting of the **El Dorado Section** *(G. D. Rucker)*, Achorn, however, went on to qualify the statement by pointing out that, since most biological weapons are often used against us by Nature itself, it is very difficult to prove that they are, or are not, the result of enemy action. This is an old art, said Achorn, reminding his listeners that, as far back as the Middle Ages, history records the use of the bodies of plague victims to spread the disease among the enemy. In modern times, defense as well as attack has become more sophisticated: new detection devices have made it possible to measure small amounts of bacteria or other materials in the air; mixed vaccines have been developed to immunize against whole groups of diseases. Best defenses today, said Achorn, are filtered air, airtight clothing for contaminated areas, and heat and sunlight for decontamination. On the plus side of the ledger, concluded the speaker, is the fact that some of the discoveries made during biological

continued on page 150

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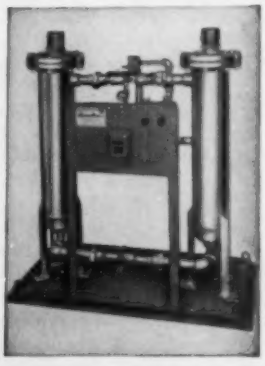

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Safeguarding lives is the aim of Oldsmobile's new electronic headlamp aiming device that makes sure every Oldsmobile has perfect "see-ability".

Night driving safety depends upon how precisely headlamps are aimed. Minute errors in adjustment can mean the difference of several square feet in light area on the road. To be completely on the "safe side", Oldsmobile aiming standards specify that lights be aimed *twice* as accurately as required by state laws.

To make certain that every light is aimed perfectly, Oldsmobile engineers developed an ingenious electronic device that effectively measures light intensity and direction, even at Oldsmobile's highest production rate.

On the assembly line, every car is automatically shuttled to the aiming platform where two probes rise out of the floor and "feel" the exact location of the car. The "eyes" of the aiming device then align themselves with the centerline of the car. A series of photoelectric cells instantly record the light intensity and direction on large dials. A built-in scanning circuit then inspects all settings of the headlamps to make certain they are accurate. If there is an error, a colored soap solution is automatically sprayed on the windshield, and the headlamps are re-aimed.

Oldsmobile takes pride in producing an automobile as advanced in every respect as modern technology can make it. However, you owe it to yourself to have your headlamps periodically checked. As part of General Motors' public-spirited "Aim to Live" program, your Oldsmobile Dealer is featuring headlamp aiming, as well as other important safety services for you. Stop in soon . . . and while you are there, take a test drive in a new Olds—sales leader of the medium price class.

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The Clarifier shown above is part of an ILLCO-WAY ionXchange installation, at a metal-finishing plant, which is used for waste disposal and water recovery. Similar Clarifiers are widely employed to clear up surface waters used by various industries — removing organic matter, hardness, alkalinity, turbidity, color, and iron, as required by specific conditions.

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In many instances it is more economical to use a Clarifier in the initial part of a system. Certain water supplies contain organic matter or turbidity which can be removed most efficiently by flocculation, or contain carbonate hardness or alkalinity which can be largely reduced by precipitation — in which situations, a Clarifier is indicated as best. *Let us analyze the water you propose to use, and advise you.*

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from page 148

warfare studies have really possessed more beneficent aspects. Among them: rapid accumulation and identification of agents dispersed in the air; isolation of crystal bacteria toxin; useful data on the effects of chemical agents on plants.

Successful development of an operational ICBM is a far different problem from the orbiting of a satellite around the earth, said J. W. Streeter, addressing the **Philadelphia-Wilmington Section** *(D. G. Evans)* a few days after Explorer I had been sent aloft. According to Streeter, Historian of Science at Franklin Institute, Philadelphia, the re-entry problem, that is, the difficulties encountered in getting a missile back through the earth's atmosphere at high speeds, and target accuracy, which involves stopping the rocket's engines at precisely the right speed, are major obstacles which have yet to be overcome. Streeter sees no reason to believe that the Russians have solved these problems either. In his opinion, Russian success was due to the fact that they made their satellite program a major effort; that they provided the necessary budget; that they gave the engineers working on the project a great deal of security (much more than our own engineers have on similar projects); and that they used U.S. "mass production" techniques to achieve their goal. In the matter of imported know-how, Streeter believes that the Russians got no more German V-2 talent after World War II than did the United States.

Giant morons

Actually, computing machines are extremely rapid morons, rather than giant brains. They respond to only two numbers: one and zero: in effect they are nothing but a sort of on-off device. This was brought out vividly to members of the **Southern California Section** *(R. D. Sheeline)* at its May meeting, where the Field Research Automatic Numeric Theatrical Integral Computer (F.R.A.N.T.I.C.) was demonstrated by John E. Sherborne of Union Oil Co. While most digital computers are fed on a diet of numbers, F.R.A.N.T.I.C. is unique in that it also needs steak and potatoes to

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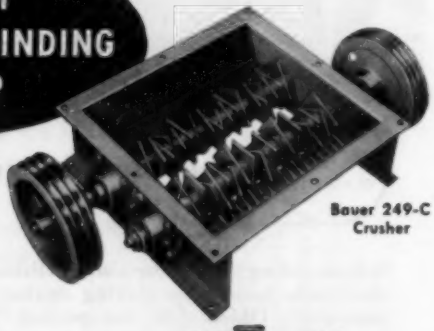
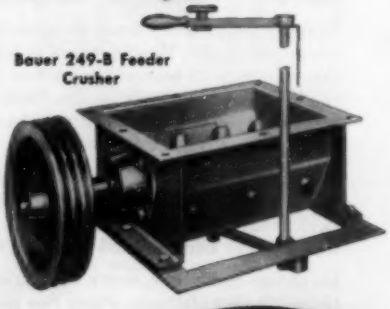
You can reduce bulky chemicals or industrial materials to a controlled, uniform, easy-to-process size with Bauer Crushers.

These units can be used independently or with Bauer attrition mills, hammer mills, breakers, granulators or fiberizers to speed the processing of virtually any type of material.

If you have a special problem in this field, the experience of our engineers and research staff is at your disposal with no obligation. You are invited to write for our No. 56 General Catalog.



Bauer 249-C Crusher



Bauer 249-B Feeder Crusher

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D. D. Dunlop of Esso Research, Baton Rouge, La. (standing, left) receives A.I.Ch.E. award for excellence in presentation of his paper "Particle Size Control in Fluid Coking," co-authored by L. I. Griffin and J. F. Moser. T. C. Landrum, chairman of the Baton Rouge Section is doing the honors. Prize paper appeared in CEP, August, 1958.

operate. The computer itself consists of three boards about 3 by 6 ft. which represent a magnetic information storage drum, a processing unit, and the controls. Actual machine functions are performed by properly-fed operators (human).

One day Technical Sessions in Texas and New York.

Oct. 3, 13th Annual Technical Meeting. South Texas Section, Galveston.

Oct. 23, All-day Symposium, New York Section, Hotel Statler, New York.

See Future Meetings (page 136) for complete details.

Also meeting

What to do if a chemical plant is attacked by a tornado? Members of the **Alton-Wood River Section** *(J. G. Huddle)* at the April meeting heard Cliff Duckworth, safety superintendent of Olin-Mathieson's East Alton plant, describe its system for coping with such disasters. Duckworth's talk was preceded by a Weather Bureau film on tornados and an exposition by Glen Stallard, chief airport meteorologist, Lambert Air Field, of official storm warning procedure in the St. Louis area. . . . The January meeting of the **Cleveland Section** *(D. P. Handke)* heard vice-president Donald L. Katz emphasize the increasing cooperation between A.I.Ch.E and its sister societies. In a following discussion on educational trends it was predicted that use and programming of computers will soon be a standard

continued on page 152

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For example, with USG's exclusive Arc-Loc movement and Mono-Unit construction, complete recalibrations can be made up to 15 minutes faster than with any other process gauge. Here's why:

NOTE that with Supergauges, adjustments for "zero shift" can be readily made from the front, with gauge in operating position and without removing pointer from the shaft. Location of positive, self-locking worm adjustment screw on *side* of pointer prevents axial distortion of pointer or bending of shaft during adjustment.

NOTE that with USG Mono-Unit design, all Supergauge internals are integrated into a single assembly which can be removed in one quick operation. Complete legends on laminated plastic dials give gauge model number and materials used in construction of components for instant identification. More maintenance minutes saved!

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Supergauges meet ASA specifications for Grade AA Test Gauges, including accuracy within ½ of 1% of scale range. They are available in a full line, embracing a wide selection of case styles (including aluminum), case sizes, pressure ranges and materials of construction.

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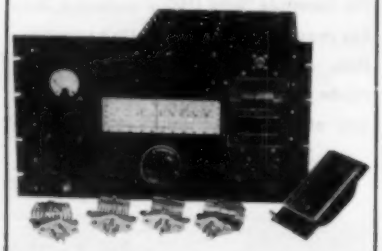
Equipment from this laboratory will be satisfactory in electronic work between 1-100 MC, both with pulses and C. W. Applications are in ultrasonics, filter analysis, integration, transient responses, time measurements, etc. The dynamic range of complete systems is over 146 db.

PG-650—High Power Pulsed Oscillator



Frequency Range 5-80 MC* in 7 ranges
Rise Time (Max.)—0.5 usec
R. F. Output Voltage (Min.) 0-300 peak to peak into 93 ohms
P.R.F. (external trigger)—0.3000 C.P.S.
P.R.F. Internal 50-2500 locking on 60 cycles
Pulse Length—1½-10 usec
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Trigger to Pulse Jitter (Max.) .005 usec
Pulse to Pulse Jitter (Max.)—.03%
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* This range may be extended with special coils from 0.5 to 150 MC.

WA-600—Wide Band Amplifier

Designed to allow complete coverage of the 6-60 MC range without adjustment or change in I.F. Strips. The output is available either at the original frequency or from a full wave detector. The r.f. jack may be used in a feed back loop or with a local oscillator as a converter.

Input Frequency 6-60 MC to 3 db points
Gain—80-90 db
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Choice of D.C. Amplifier Flat to 2 KC for band pass measurements with Swept Oscillator.

PA-620—Preamplifier, In conjunction with WA-600 units which provide power, this device acts as an impedance matching device and narrow band selector to provide a 20-30 db improvement in S/N ratio.

ATT-603, ATT 650—Precision Attenuators, Ranges of 0-122 with 1 watt 1% precision resistors ensure wide utility.

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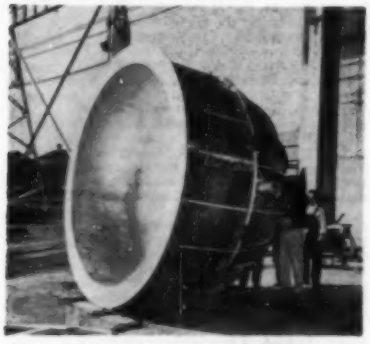
local sections

from page 151

subject in all chemical engineering curricula. In February, the **Clevelanders** gathered to hear C. F. Prutton on "Location Problems and Evaluation for a Chlorine Plant". . . . How to double your money in a short time through purchase of selected chemical stocks was explained in detail by Eugene E. Burlingame of Arthur D. Little to the March meeting of the **Charleston Section** *(L. L. Cavender)*. Official title of his talk was "Financial Aspects of the Chemical Industry." . . . Corrosion—cause and prevention —was the theme of the **Detroit Section's** March get-together. The speaker —E. G. Holmberg, Corrosion Engineering Section, International Nickel. . . . The Russian have used no rocket fuels of which we were not aware, opined Ralph G. Swann, assistant director for research and rockets at Redstone Arsenal, speaking to the **East Tennessee Section** *(J. C. Umberger)* at its April meeting. The large Russian payloads, as in Sputnik II, can be attributed, continued Swann, to the fact that they started on large propulsion devices before the United States. Molecular Sieves—properties and uses—were explained by J. D. Steinhagen of Linde Co. to the **East Tennessee** May meeting. . . . The mathematical equations involved in launching an earth satellite were elucidated to the May meeting of the **Kansas City Section** *(L. S. DeAtley)* by Jerry Taborek of **Phillips Petroleum**. Taborek, born in Czechoslavakia, was trained in Germany, but fled at the end of World War II to escape deportation to Russia. . . . Also in May, an expert from the Surgeon-General's office, Lt.-Col. James B. Hartgering, spoke to the **National Capitol Section** on "Radiation and Man"—the technical aspects of the fall-out problem. . . . At the **Midland Section** *(J. Eichhorn)* in March, a panel, moderated by vice-president Donald L. Katz, attacked the thorny question of professional registration for engineers. Panel members were: Garvin H. Dyer, NSPE; Granville M. Read, Du Pont; F. J. Van Antwerpen, secretary, A.I.Ch.E.; Blaine B. Kuist, Fluor Corp. . . . Molecular Sieves again—at the **Nashville Section** *(J. E. Murphy)* in May and at the **New Haven Section** *(H. Borsvold)* in March. Speakers were J. D. Steinhagen and R. A. Jones, respectively, both of Linde Co. . . . Plasma, the "fourth" state of matter, its handling, and its use in ultra high temperature processes, was the subject of Thomas B. Drew of Columbia before the **New York Section** *(Chester Knowles, Jr.)* in March. Concluding meeting of the season in New York (June) was devoted to an off-beat totpic—"The Engineering of Consent." Speaker Robert D. Stuart, editor of Advertising Agency; feature of his talk was a discussion of the new sensation in the advertising world, "subliminal projection". . . . "St. Patrick, Kirkpatrick, and the Sputniks," or "Around the World in Fifty Years with Chemical Engineering"—being the story of the A.I.Ch.E.—birth, growth, and goals. Speaker . . . S. D. Kirkpatrick of McGraw-Hill before the March meeting of the **New Jersey Section** *(R. J. Boyle)*. . . . At the April meeting of the **Central Ohio Section,** past president Henry Rushton reviewed "The Technology of Mixing". . . . Education and home life of the Italian student of chemical engineering featured a talk by J. O. Maloney in March at the **Oklahoma Section**. *(A. J. Andrews)*. Robert N. Sears of Phillips Petroleum, speaking at the **Oklahoma** April session, talked on "Middle East Oil in Tomorrow's World." In May, also in **Oklahoma,** the topic was "Dynamic Analysis in Chemical Engineering"; speaker—L. W. Morgan of Phillips Petroleum. . . . Interesting sideline for chemical engineers was a talk on "Gems and Gem Materials" by Irving Brown, Jr. of Linde Co. before the **Philadelphia-Wilmington Section** *(D. G. Evans)* in January. . . . Donald Q. Kern brought the members of the **South Texas Section** up to date on the influence of fouling factors in heat exchange at its May meeting. . . . Also in May, Kern appeared before the **Western New York Section** to speak on "Mechanically-Aided Thermal Processing". . . . The Challenge of Outer Space—a film report by Werner Von Braun—featured the January session of the **Texas Panhandle Section**. . . . In March, the **Panhandle** members viewed another film, this time on Dowtherm—its properties and uses. . . . The same film on Dowtherm was seen by the **Twin Cities Section** in April. . . . Nuclear Engineering was the theme of the January meeting of the **Washington-Oregon Section.** Speakers were: R. W. Moulton, University of Washington; and A. L. Babb, also University of Washington. . . . The first sub-section of the A.I.Ch.E. has been formed. This is the **Brazosport Sub-Section** of the **South Texas Section.**

Conversion of raw petroleum into pure carbon for electrodes has been increased by 720 tons/day with the completion of a new calcining plant at the Robinson, Ill., works of General Carbon and Chemical Co. Heart of the new unit, designed and built by Fruin-Colnon Contracting Co., consists of two 10-ft. diameter, 180-ft. long refractory-lined rotary calciners.



A giant 10-ft diameter aluminum mold, built by Chicago Bridge & Iron, will be used by a manufacturer for the molding of resin-impregnated fibreglass radomes. The mold's interior surfaces are machined to better than 63 micro-inch finish. #

Sun Chemical has purchased the Coating Materials Laboratories, Nutley, N.J., manufacturers of industrial coatings and finishes. The company will be operated as an autonomous division in Sun's Paints and Finishes Group. #

A 50% increase in manufacturing capacity for fine organic chemicals has resulted from the startup of a new $4.6 million chemical plant at Eli Lilly's Tippecanoe Laboratories, Lafayette, Indiana. #

A high-energy fuel pilot plant for the Air Force has gone into operation at the Henderson, Nevada, plant of American Potash & Chemical; goal of the new facilities is to develop a large-scale production method for an alkyl borane fuel. Designers and builders of the unit are AFN, Inc., jointly owned by American Potash, Food Machinery & Chemical, and National Distillers. #

Antiozonants will be added to the products to be manufactured at the new Henry, Ill., general chemicals plant of Goodrich Chemical. Completion of the expansion is slated for spring of 1959.

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- agitator keeps precipitates from settling, assuring constant solution strength
- Y-type strainer removes harmful solids, prevents pump damage

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A. I. Ch. E. candidates

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions. These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before Oct. 15, 1958, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

ASSOCIATES

Abney, Jesse Allen, *Fruithurst, Ala.*
Arendt, John P., *Clinton, Iowa*
Armstrong, Andrew A., Jr., *Lockport, N. Y.*
Audet, Louis A., *Salem, Mass.*
Auster, Albert M., *New Orleans, La.*
Avsenek, Stefanie C., *Cleveland, Ohio*
Bailey, George, *Richland, Wash.*
Baird, David Wallace III, *Louisville, Ky.*
Baker, Ralph Lee, *Louisville, Ky.*
Blackwell, Frank J., *Decatur, Ala.*
Bopp, Charles P., *El Segundo, Calif.*
Borofsky, Joel H., *Los Angeles, Calif.*
Boucher, Kenneth E., *St. Louis, Mo.*
Braddock, David, *Chicago, Ill.*
Breckenridge, Tom, *Donna, Tex.*
Brown, Robert D., *Nashville, Tenn.*
Burns, Pierce, *Brownwood, Tex.*
Busa, James V., *Pittsburgh, Pa.*
Butterbaugh, William H., III, *Borger, Tex.*

Campbell, Walter R., *Waukegan, Ill.*
Canfield, Robert C., *Belleville, Ill.*
Carr, Donald Walter, *Burbank, Calif.*
Cengel, John Anthony, *Whiting, Ind.*
Chick, Harry P., *Youngstown, Ohio*
Ciriacks, John A., *Milwaukee, Wis.*
Clement, Blanton, Jr., *Charleston, W. Va.*
Comer, Roger C., *Huntsville, Ala.*
Cosart, William P., *Los Altos, Calif.*
Cottrell, James H., *Lake Charles, La.*
Courtney, L. C., Jr., *Houston, Tex.*
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Cremer, Byron R., *Long Beach, Calif.*
Criswell, Larry G., *Wyandotte, Mich.*
Crane, Theodore P., *Oakman, Ala.*
Culberson, Robert A., *Louisville, Ky.*
Culver, Everett E., *Maplewood, La.*
Curran, Bruce L., *Louisville, Ky.*

Dale, Don, *Lufkin, Tex.*
Dawn, Robert C., *Wyandotte, Mich.*
Dayton, William F., *Endicott, N. Y.*
Davis, Charles M., *Charleston, S. C.*
Deckman, Don Arthur, *Texas City, Tex.*
Duda, J. Larry, *Belle Vernon, Pa.*
Duyungan, Orencio Noel, *Seattle, Wash.*

Economou, Solon S., *Worcester, Mass.*
Eifler, Charles T., *Louisville, Ky.*

Falco, Michael, *Brooklyn, N. Y.*
Faulkner, Fred Eugene, *Asheville, N. C.*
Finney, James D., *Louisville, Ky.*
Fisher, Edwin E., *Bay City, Tex.*

Gansler, Henry R., *Everson, Wash.*
Geisler, Robert L., *Dayton, Ohio*
Gilliam, Ivey W., *Graham, N. C.*
Giralt, Emilio E., *Havana, Cuba*
Givey, Robert D., *Rye, N. Y.*
Gladstone, Valentin Michael, *Seattle, Wash.*
Goodrich, David Wayne, *Healdsburg, Calif.*
Greco, Thomas H., *Rochester, N. Y.*
Gruss, Donald, *Philadelphia, Pa.*

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Harakas, Nick K., *Greenville, S. C.*
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Hass, Paul D., *Decatur, Ill.*
Helbig, James E., *Baytown, Tex.*
Hemminghaus, Roger R., *Decatur, Ala.*
Henson, John Robert, *Glencoe, Ala.*
Hiemer, Gerold F., *Waukegan, Ill.*
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Johnston, James E., *Maplewood, La.*
Jones, Irby Cullen, Jr., *Florala, Ala.*
Junginger, G. William, Jr. *Philadelphia, Pa.*

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Lamb, William B., *Evanston, Ill.*
Lasota, Roman, *Philadelphia, Pa.*
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Lemons, Kenneth N., *Throckmorton, Tex.*
Lewis, Warren L., *Los Angeles, Calif.*
Lontz, Hubert M., *Washington, Pa.*
Lunn, F. James, *Long Beach, Calif.*

Maginnis, Richard, *Chicago Heights, Ill.*
Magyar, Steve J., *Maple Heights, Ohio*
Malone, Noel H., Jr., *Kingsport, Tenn.*
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McCord, Rufus N., *Saltville, Va.*
Michael, Thomas C., *Philadelphia, Pa.*
Mikolaj, Paul G., *Cleveland, Ohio*
Miller, Donald G., *Wheat Ridge, Colo.*
Morginstern, Hans G., *Lindenhurst, N. Y.*
Morphew, Alan T., *Idaho Falls, Idaho*
Morris, John L., *Wichita, Kansas*

Neely, David L., *Parker, Pa.*
Newton, Richard C., *Delmar, N. Y.*
Nilson, Robert M., *Buffalo, N. Y.*

Ohn, Gerald E., *Milwaukee, Wis.*
Olson, Ralph W., *Menomonie, Wis.*
Ott, Ronald R., *Portland, Oregon*

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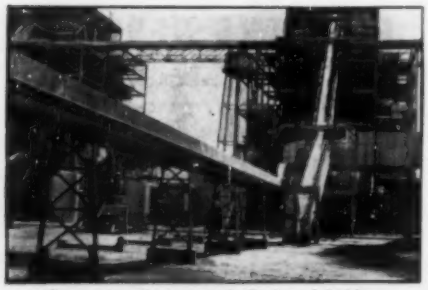

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7. No explosion risks
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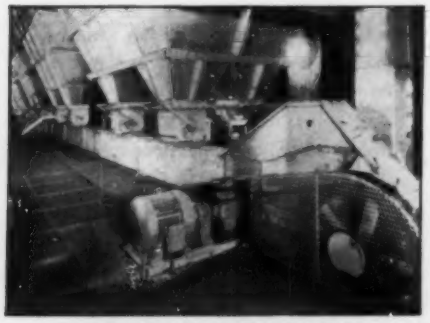

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Romero, G. L. *Brooklyn, N. Y*
Roper, Robert S., *Cleveland, Ohio*
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Ruchlin, Harold, *West New York, N. J.*
Russell, Donald Allen, *Chillicothe, Ohio*

Sarver, George L., Jr., *Groves, Tex.*
Sawyer, Willard H., *Baton Rouge, La.*
Schultz, Norman L., *San Antonio, Tex.*
Schwartz, Seymour D., *Los Angeles, Calif.*
Scott, Charles Benton, *Pasadena, Calif.*
Seiner, Jerome A., *Pittsburgh, Pa.*
Selph, Curtis C., *Columbia, S. C.*
Smith, Russell U., *Tyler, Tex.*
Spring, Marshall W., Jr., *Louisville, Ky.*
Stancik, John W., *New York, N. Y.*
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Tucker, H. Richard, *Peoria, Ill.*

Vahlsing, David H., *Hastings, Mich.*
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Vanderlip, Jack A., *Canoga Park, Calif.*

Waggoner, Raymond C., *Lake Jackson, Tex.*
Walton, Richard J., *Barberton, Ohio*
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Webster, Jerome E., *Cassville, Wis.*
Weiner, Stanley, *Philadelphia, Pa.*
Wigfield, Fred, III, *New Cumberland, Pa.*
Winters, Howard L., *Dallas, Tex.*
Wivchar, Milton W., *Cleveland, Ohio*
Wojcik, Leopold J., *Philadelphia, Pa.*
Wolgast, Arnold Klehm, *Corpus Christi, Tex.*

Zengel, Alan, *Quincy, Ill.*

The first filteraid plant in Mexico has been put on stream in Mexico City by Great Lakes Carbon. The new 6,000 ton/year plant is producing a new type of filteraid made from **perlite**, a siliceous lava rock, of which there are large deposits about 130 miles east of Mexico City. #

Formaldehyde production will be raised from 80 to 135 million lb./year at Montecatini's Castellanza, Italy, plant. The plant uses a process involving the air oxidation of methanol with a metallic oxide catalyst. The usual dehydrogenation step is eliminated and, since the 37% aqueous solution of formaldehyde contains less than 1% of methanol and less than 0.008% of formic acid, distillation equipment and ion exchange columns are said not to be necessary. #

Oil-resistant synthetic rubbers and high-impact plastic materials will be made in France by Societe d'Electro-Chimie, d'Electro-Metallurgie et des Acieries Electriques (UGINE) under license from United States Rubber Co. UGINE, a major French producer of alloy steels and electro-chemicals has expanded into organic chemicals since World War II. #

7500 gal. Sprinkler Tank 84' x 26'3"

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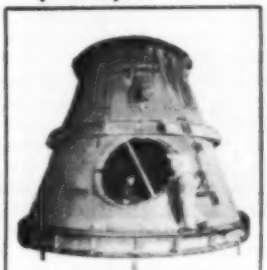
X-RAY INSPECTION, MAGNAFLUXING AND DYE CHECKING FOR QUALITY CONTROL

KOVEN equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks; high vacuum testing.



A.S.M.E. Steel Reducer 13' large diameter; 6' small diameter; 18' high, 7/8" steel throughout.

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Fabrication to all A.S.M.E. Codes

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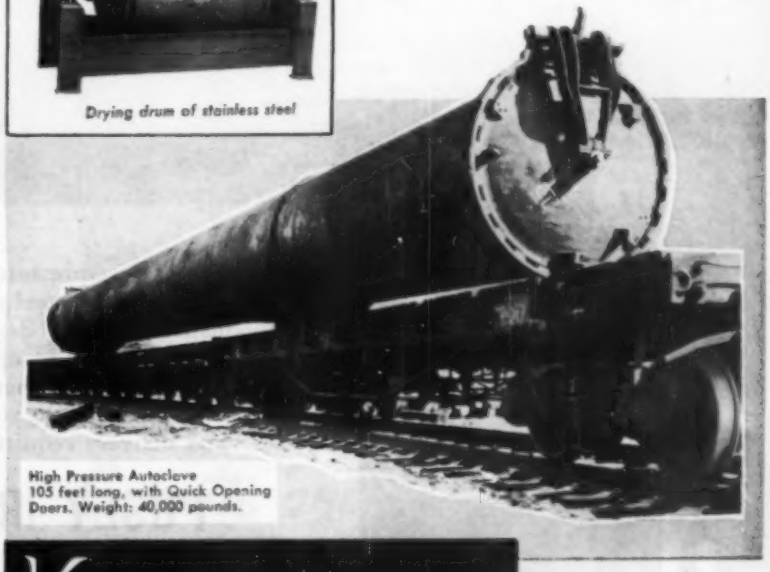
SEE SWEET'S FILE AND CHEMICAL ENGINEERING CATALOG

Drying drum of stainless steel



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Engineering Fund Drive Opens in Cincinnati

Local sections of the Founder Societies in Cincinnati representing ASCE, ASME, AIEE, and A.I.Ch.E. have joined forces in a combined effort to canvass a total of about 1,500 individual members in the Cincinnati area in support of the Joint Member Gift Campaign for the United Engineering Center Building Fund. The effort is being seconded by a sponsoring committee comprised of representative leaders of the engineering profession in the Cincinnati industrial community. Shown at a recent planning session are (left to right): Kenneth H. Pettengill, Arnold Hoffman & Co. (A.I.Ch.E.); Cornelius Vandmacher, associate dean, College of Engineering, University of Cincinnati (ASCE); Ernest S. Fields, president, Cincinnati Gas & Electric (chairman of local sponsoring committee); Harry S. Progler, Westinghouse Electric (AIEE); and Lester L. Bosch, Bosch & LaTour (ASME).

Preston L. Hill has been named chief of the Manufacturing Methods Branch of the Air Material Command, U. S. Air Force at Wright-Patterson Air Force Base near Dayton, Ohio.

F. Dudley Chittenden has been appointed to the new post of manager of Marvinol operations for the Naugatuck Chemical Division, U. S. Rubber Co. Chittenden will direct sales, production, and development of Marvinol vinyl resins.

Chas. Pfizer & Co. has announced appointment of **Robert D. Newton** as assistant director of operations research. Formerly a senior analyst, Newton joined Pfizer in 1946 as a production supervisor.

Chairman of the Gordon Research Conference on Instrumentation for 1959 will be **Clifford E. Berry**, assistant director of research, Consolidated Electrodynamics Corp.

Dysart E. Holcomb, president of Texas Western College since 1955, has resigned to become director of research and development for El Paso Natural Gas Co.

Posey-fabricated Propane Storage Tank . . . 64' long, 9' diameter. Shell 1" thick, heads ½" thick. Capacity 30,000 gallons liquid, working pressure 250 pounds per square inch.

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Let us quote on your next pressure vessel job. Since 1910, we have produced welded steel structures to meet a wide variety of industrial needs. Today Posey Iron has the experience, facilities and manpower to fabricate vessels of any size, type or metal. Write for information about our installations in your industry. Your specifications and delivery requirements will be rigidly observed.

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A new New York firm, Lauren B. Hitchcock Associates, will specialize in technical planning, organization, and new product development for the chemical process industries. Principals in the newly-formed firm are: **L. B. Hitchcock,** formerly vice-president of Quaker Oats Chemicals Dept., president of National Dairy Research Laboratories, and president of the Air Pollution Foundation; and **General Edwin Cox,** previously vice-president of Virginia-Carolina Chemical Corp.

Edwin N. Woistmann has been named vice-president of Processes Research, Inc. of Cincinnati and New York. Before joining Processes Research about two years ago, Woistmann had been associated with Foramino, Inc. as vice-president, and with the O-Cel-O Division of General Mills as chief engineer.

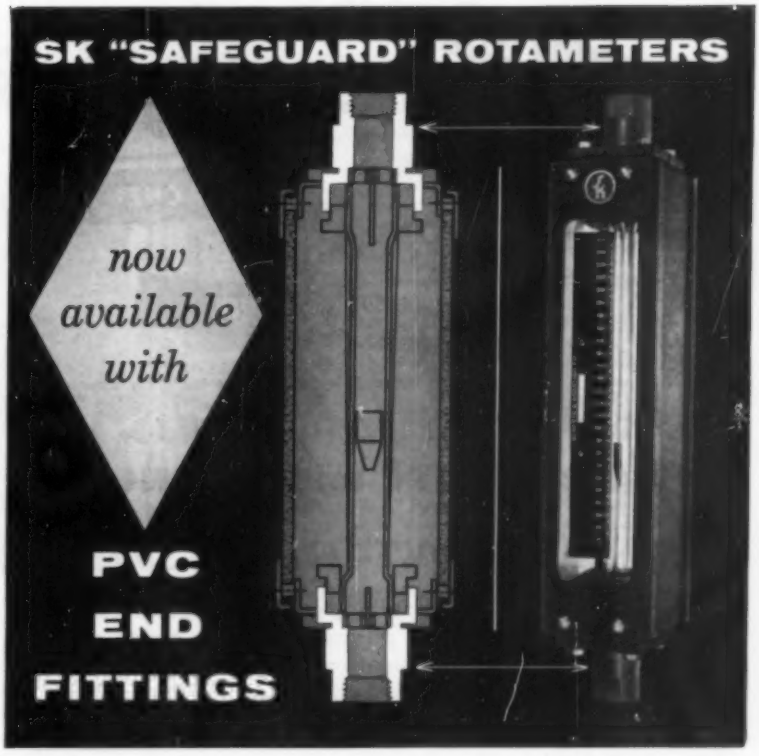
The University of Chicago has appointed **Max S. Peters,** professor of chemical engineering, as head of the Division of Chemical Engineering in its Department of Chemistry and Chemical Engineering. Peters came to Illinois in 1951 as assistant professor of chemical engineering.

After 32 years of service, **George D. Beal** will retire on August 31 as a director of research at Mellon Institute. In addition to a notable career in chemical research, pharmaceutical investigation and education, and research management, Beal took a leading part for 25 years in the periodic revision of the United States Pharmacopeia.

Robert E. Workman, former manager of the Chemical Division of Goodyear International, has been named to the newly-created post of assistant general manager of the Chemical Division of Goodyear Tire & Rubber Co.

Ralph C. Barley has joined van Ameringen-Haebler, Inc. as manager of the engineering department. Barley was was formerly senior process project engineer at American Cyanamid in Bound Brook, N. J.

continued on page 158



New Bulletin 18RG describes SK's line of "Safeguard" Rotameters and gives detailed instructions for liquid and gas sizing. A special sheet lists fluids for which PVC is recommended. Send for your copy.

Visit our Booth No. 1449 at the Instrument-Automation Conference & Exhibit, Philadelphia, Sept. 15-19, 1958.

SK "Safeguard" Rotameters with Polyvinyl Chloride (PVC) end fittings are now available for measuring the flow of hydrochloric acid, sulphuric acid, and the many other chemicals for which PVC is recommended. As a matter of fact, these new Rotameters are already being used for corrosive fluid service with excellent results.

Two facts regarding this new PVC "Safeguard" Rotameter are of particular importance.

First, this instrument provides a Rotameter with chemical resistant end fittings and rotor at much less cost than a similar instrument with these components made of other special corrosion resistant materials.

Second, the Fig. 18275 "PVC" Rotameter incorporates all of the features of the SK "Safeguard" line—one piece fabricated steel case, tube and rotor versatility, heavy safety glass windows, adaptability to panel mounting and to electric or pneumatic transmission for remote recording and controlling of fluid flow, and others.

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ANY CORRODENT!

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Fibercast, made from thermosetting reinforced epoxy resins, is long-term pipe economy, particularly where highly corrosive conditions are a constant, costly problem. Frequent replacement of piping used to handle corrosive liquids and gases is no longer necessary when Fibercast is installed.

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- Takes high temperatures
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- 20-ft. joint lengths
- Standard iron pipe O.D.
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Name _____ Title _____
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people in management & technology

from page 157

Two new members of the board of directors of Vulcan-Cincinnati are **Ronald Jeanmougin** and **W. Douglas Beers.** Jeanmougin has been associated with Vulcan since 1945, when he became controller. Since joining the company in 1951, Beers (above) has held several positions including that of general manager of engineering and construction.

Three major promotions at American Potash & Chemical have resulted from the recent merger of Lindsay Chemical with American Potash: **George T. Deck,** formerly plant manager of the AP&CC subsidiaries, American Lithium Chemicals and San Antonio Chemicals, both at San Antonio, Texas, becomes vice-president and technical general manager of the renamed Lindsay Chemical Division at West Chicago, Ill.; **Russell S. Sunderlin,** plant manager of AP&CC's Los Angeles plant, will succeed Deck at the Texas plants; and **Harold Mazza,** research manager at the Los Angeles facility, becomes plant manager.

W. C. Witham becomes assistant director in charge of industrial relations at the Peoria, Ill., Northern Regional Research Laboratory of the U. S. Department of Agriculture. Since 1955, Witham has been assistant manager for program coordination at Armour Research Foundation, Chicago.

William T. Witter, formerly area development manager for Monsanto Chemical's Overseas Division, St. Louis, has been assigned to Monsanto Argentina, S.A.I.C. Also at Monsanto, **Joseph F. Frantz** has joined the company's Lion Oil Co. Division at El Dorado, Ark.

Upon retirement as Chief Chemical Officer of the U. S. Army on September 1, **Major General William M. Creasy** will join the Lummus Co. as vice-president. Creasy will serve as director of the Lummus Engineering Development Center.

Among recent graduates who have accepted research positions with the Armstrong Cork Co. is **Richard E. Dagle.**

continued on page 160

KUTZTOWN Skill

creates an AMMONIA STILL

with an overall diameter of seven feet, six inches.

For many years the Kutztown Foundry & Machine Corporation has produced castings used in evaporation, distillation and decomposition operations and allied processes . . . castings produced in materials capable of handling liquids under pressure and heat . . . that are thoroughly sound, able to withstand severe hydrostatic tests . . . castings with long and excellent performance records!

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Solved Them With...

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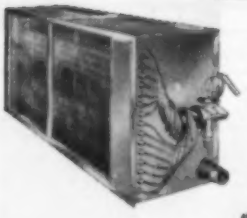
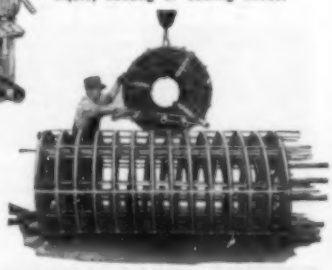


Rempe Fin Type Coils are ideally suited for handling all types of corrosive air mixtures, gas or liquid, heating or cooling needs.



We have complete facilities and tested technique in the fabrication, welding and finishing of pipe coils made from all types of stainless steel.

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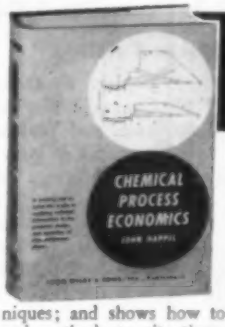
Bridges the gap between theory and practice . . .



1. CHEMICAL PROCESS ECONOMICS

By JOHN HAPPEL, New York University

A practical guide to the application of technical knowledge to the economic design and operation of chemical-process plants. Develops techniques for handling problems through basic, mathematically developed relationships; provides specific information on applying these techniques; and shows how to apply the previously discussed theories and methods to situations involving over-all plant evaluation and economic balances. Includes a discussion of the problems of selection of new equipment, design of process plant components, and the operation of existing plants.

Chapter headings: Principles of Economic Balance. Expanded Economic Balance Equations. Special Mathematical Techniques. Notes on Cost Estimation. Risk, Return Rate, and Investment Recovery. Over-all Consideration in Project Analysis. Economics of Component Units. Social Values in Engineering Economy.

1958 291 pages Illus. $8.50

2. AUTOMATIC PROCESS CONTROL

By DONALD P. ECKMAN, Case Institute of Technology

A complete and up-to-date treatment of the important principles of automatic control, emphasizing modern block diagram and frequency techniques in process control. Coverage includes: The Science of Automatic Control. Process Characteristics. Controller Characteristics. Closed Loop in Automatic Control. Measuring (Feedback) Elements. Controlling Elements. Final Control Elements. Process Instrumentation. Sinusoidal Analysis. Stability Analysis.

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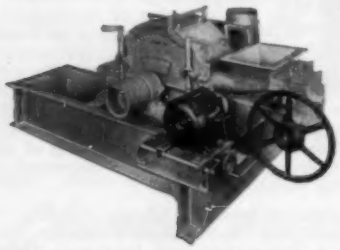

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people in management & technology

from page 158

Barnett F. Dodge, chairman of the Chemical Engineering Department at Yale, and **Walter E. Lobo,** consulting engineer of New York, are among the United States delegates who will attend the Fifth Convention of the Pan American Federation of Engineering Societies (UPADI) in Montreal, September 2-6, 1958. UPADI member for the United States is Engineers Joint Council.

Chemical problems of manned space flight will be the province of **Jack D. Zeff,** who has been appointed a research engineer with American Machine & Foundry's Mechanics Research Division, Chicago. Zeff was formerly a chemical production engineer with the Toni Division of the Gillette Co.

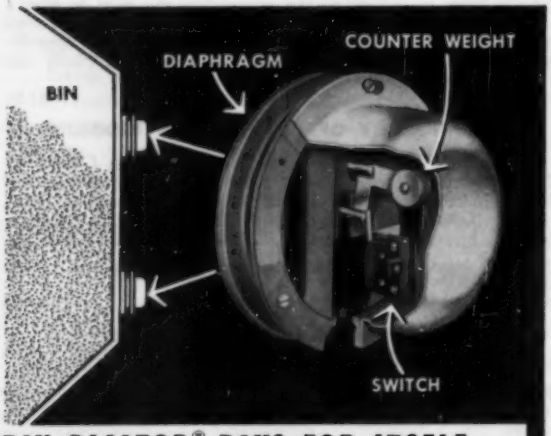
E. L. Dougherty joins the Reservoir Mechanics group in oil field research at the La Habra Laboratory of California Research Corp. as a research engineer. Dougherty comes to California Research from the Dow Chemical Co.

At Humble Oil & Refining's Baytown, Texas, refinery, **Sam Bozich** (left) is promoted to foreman of the polymerization unit at the Butyl rubber plant, and **M. G. Whitcomb** and **W. E. Stevens** have been made senior engineers in the Technical Division.

The 1958-59 Westinghouse Achievement Scholarship at Clemson College has been presented to **Charles H. Barron,** senior in chemical engineering. Barron is secretary of the Clemson chapter of A.I.Ch.E. and was one of the winners of the 1957-58 A.I.Ch.E. Student Award.

Roy Gealer has joined Ethyl Corp. research laboratories in Detroit as a chemical engineer. At Ethyl in Baton Rouge, **Albert M. McConnell, Jr.** will be a chemical engineer in Technical Service, while **Marcelian F. Gautreaux, Jr.** becomes head of Engineering and Mathematical Sciences in the Research and Development Department.

continued on page 162



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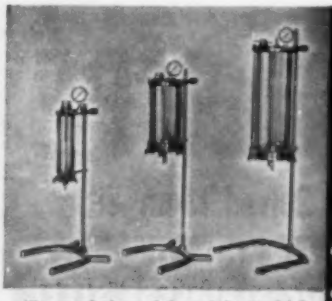

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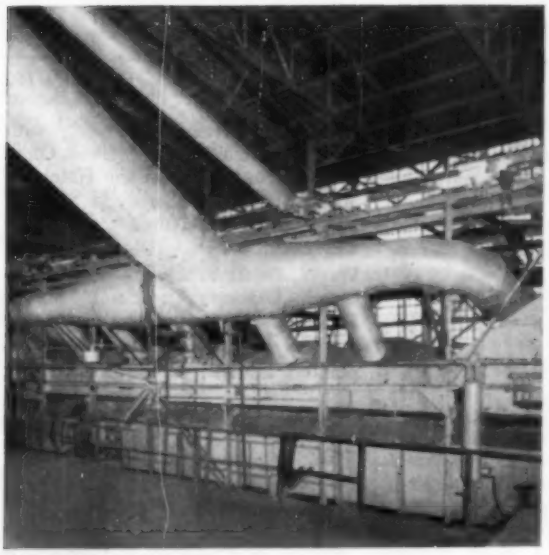

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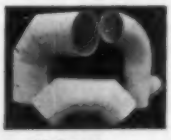

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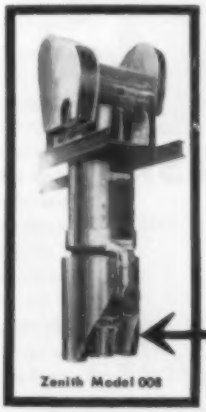

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from page 160

Martin E. Roberts has been elected vice-president and a director of the Lummus Company Canada Limited. Roberts joined the Lummus Co. in 1946 as a process engineer. In 1954, he was assigned to Lummus' London office, and subsequently, in 1956, became manager of the firm's Canadian office in Montreal.

Frederick A. Gilbert has been elected vice-president of Food Machinery and Chemical Corp. Associated with FMC and one of its predecessor companies for a total of more than 23 years, Gilbert began as a control chemist in 1935 with the former Buffalo Electro-Chemical Co. (now the Becco Chemical Division of FMC).

F. M. Tiller, dean of the University of Houston Cullen College of Engineering, has accepted a six-week assignment in Ecuador from the Fulbright Commission.

George D. Creelman, formerly with Creelman Associates, Cleveland, Ohio, will join the faculty of the Hotchkiss School, Lakeville, Conn., in September of this year as master of physics and chemistry.

W. W. Boisture has joined Esso Research Laboratories, Baton Rouge, La., as an engineering associate.

William B. Yarborough has been appointed assistant to the president of Allied Chemical's National Aniline Division. For the past five years, Yarborough has been chief engineer of Allied's General Chemical Division. Also at Allied Chemical, **Cortez P. Hackett,** vice-president of Solvay Process Division, has been named director of research and development for the corporation. Hackett has been director of development for Solvay from 1954 until last December when he was made vice-president.

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people in marketing

Promotions at Heil Process Equipment Corp. include: **Robert I. Peters,** formerly Western Division sales manager, to assistant chief engineer; **R. E. Scheel** to Western sales manager; and **R. A. Brown** to Chicago sales engineer.

Officers of Grace Electronic Chemicals, newly-formed Grace subsidiary, will be **Lewis C. Reid,** president, and **Robert H. Herrmann,** vice-president. Both men were formerly associated with Davidson Chemical Division of Grace. The new company will act as U. S. sales representative for International Metalloids, Puerto Rico, which will produce ultra-high purity silicon.

Humble Oil & Refining has transferred four chemical engineers from its Research and Development Department at Baytown, Texas, to its Marketing Department in Houston. They are: **E. W. Lewis, J. R. Miller, J. P. Peet,** and **D. H. Willson.**

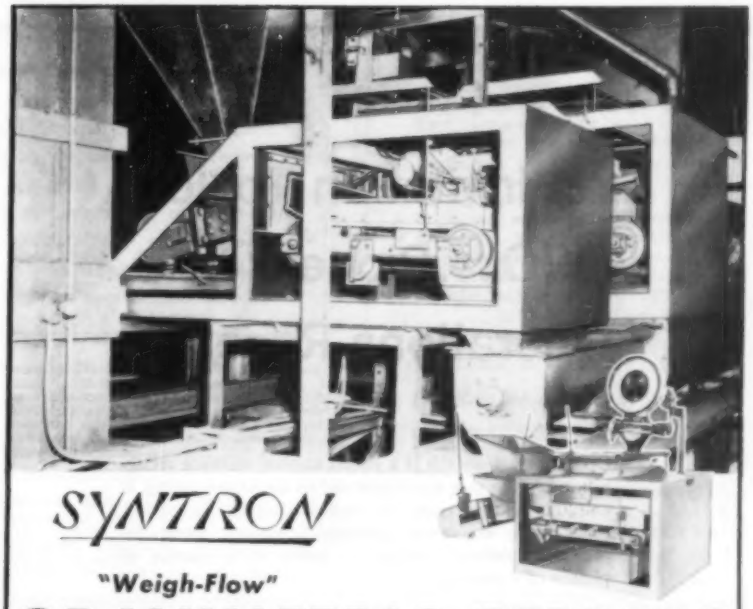
Graver Water Conditioning Co. has formed a new Foreign Operations Department, of which **Jesse D. Crell** will be manager.

Arthur I. Mendolia, assistant director of sales of Du Pont's Electrochemicals Department, has been named assistant general manager of the department. Mendolia started with Du Pont in 1941 as a chemist at the Niagara Falls, N. Y. laboratory.

Three changes have been announced in the sales organization of Mobay Chemical Corp. **L. Dean Tyler,** formerly manager of Mobay's Eastern Sales District, becomes manager, foam chemical sales, in the company's general sales office in Pittsburgh.

Harvey K. Waters, formerly of Whiting Corporation's Charleston, N. C. district office, has been named manager of the company's new district office at Minneapolis, Minn. **John N. Brown,** previously associated with Swenson Evaporator Co. has been transferred to Whiting's district office in Chicago.

continued on page 166



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people in marketing

from page 163

Donald H. Bryan, previously West Coast sales representative, will be manager of the Eastern Sales District. Bryan will be replaced in the Los Angeles post by **Harold D. Ulmer,** who has been with Mobay's Technical Service group since 1954.

H. M. Rodekohr has been promoted to be head of Economic Evaluation in the Research and Development Department of Ethyl Corp. at Baton Rouge, La.

Chemical Construction announces appointment of **Samuel Strelzoff** to the newly-created position of assistant to the president responsible for technical development and sales of special projects on a world-wide basis. Strelzoff has been general sales manager of Chemico since 1954. Replacing Strelzoff as general sales manager will be **David Fulton,** formerly sales manager of the Lummus Co. New York Division.

Du Pont has named **William W. Wingate** manager of the Mid-Continent Region of its Petroleum Chemicals Division, Tulsa, Okla. Wingate succeeds **Charles D. Towery,** who becomes manager of the Gulf Coast regional office, Houston, Texas.

Necrology

W. Hale Charch, 60, director of the Pioneering Research Laboratory, Du Pont. Charch led the research group which developed moistureproof cellophane in 1927, and was associated with the early pioneering work on Orlon and Dacron.

Edward H. Conroy, 67, director of laboratories, Tennessee Corp., College Park, Ga.

Samuel W. Martin, 47, vice-president and director of research and development, Great Lakes Carbon Corp.

Milan G. Arthur, 44, chief valuation engineer, Union Oil of California.

William F. Durand, 99, past president of ASME. His contributions to hydrodynamics and aerodynamics are considered fundamental in the field.

Warren W. Otis, 62, former production manager, National Aniline Division, Allied Chemical.

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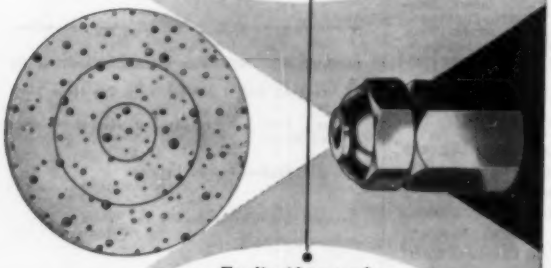

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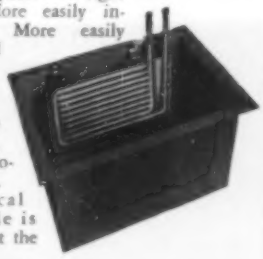

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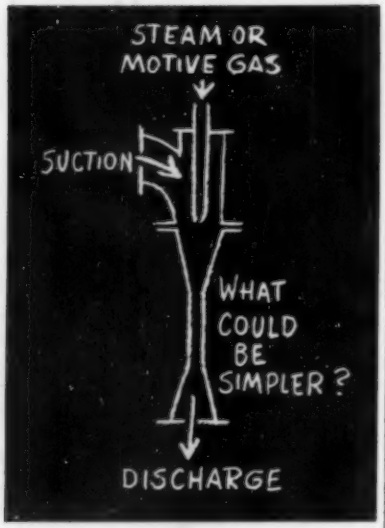

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news and notes of A.I.Ch.E.

Editorial Salutes to A.I.Ch.E.: Many fine tributes were paid to the Institute on the occasion of its Fiftieth Birthday by the national technical press. Nice things were said about us by *Chemical Engineering*, published by McGraw-Hill . . . John Callaham, Editor, and Sidney Kirkpatrick, Editorial Director, for their article actually had a birthday cake baked and photographed (and later eaten by the staff). . . . *Chemical Processing*, published in Chicago, had an interesting article on us prepared by John Vaaler, Editor, and Ted Meinhold, Associate Editor . . . Ted, incidentally, is Secretary of the Chicago Local Section this year. . . . There are news stories in other magazines; for instance the May-June issue of *Ethyl News*, published by the Ethyl Corporation, has a two-page article on the A.I.Ch.E. Golden Jubilee and the important work of the chemical engineer, which ends with the observation that the businessman of 2008 may attend the hundredth anniversary of A.I.Ch.E. on the moon, "but wherever it is held, today's and tomorrow's chemical miracles will be as commonplace as the startling innovations we have enjoyed since 1908." . . . The publication *British Chemical Engineering* paid us an unusually warm tribute, which we are having reprinted and distributed to all officers and committee members. Copies will be sent to anyone requesting them.

New Directory Supplement: A supplement to the 1957 A.I.Ch.E. directory has just been issued. Any member wishing a directory plus a supplement should get in touch with us . . . a postcard will do.

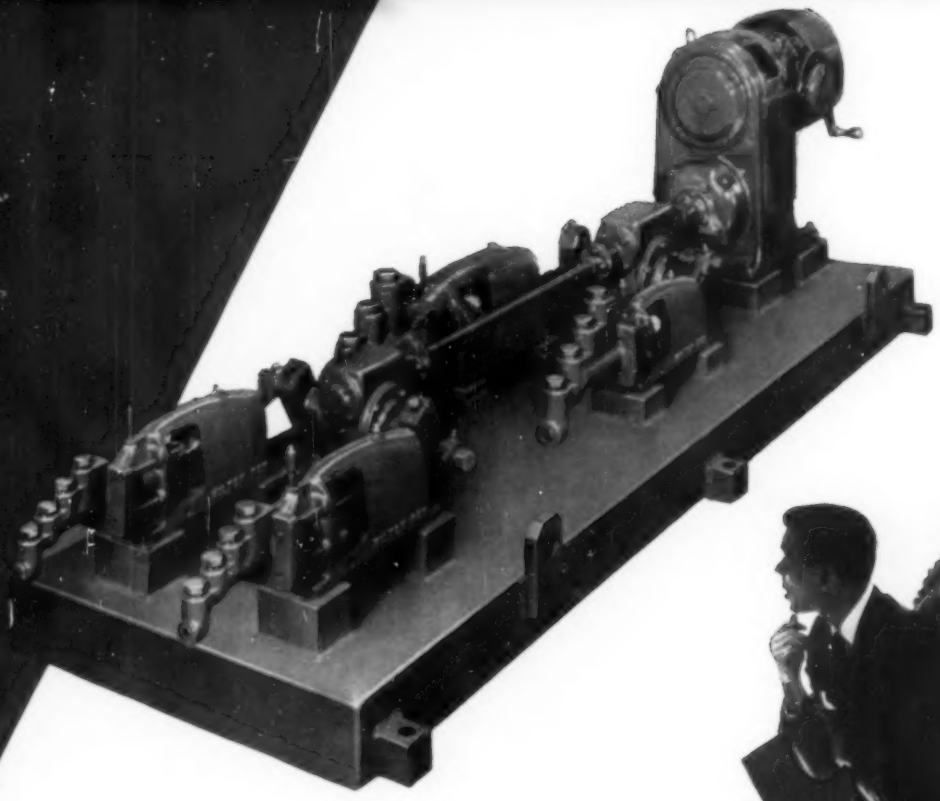
Computer Programs: An exciting development for chemical engineers in the computer field came out of the June meeting of Council, which established an *ad hoc* committee, with W. M. Carlson of the Du Pont organization as chairman, to consider the formation of computer-program interchange. . . . A report by the committee will be made in three months.

Local Section Process Control Course: The Western New York Section of the A.I.Ch.E. and the local section of the Instrument Society of America are sponsoring an evening course in Process Control Engineering to extend from September through January. Fifteen lectures are planned in the local high school, where the course will be coordinated with the adult school. Basic principles as well as application to the process field are to be covered. While quite outside the usual adult education program, the theme fits in with the industrial activity of the area. This is one important way in which Local Sections can serve the community and the profession.

Pittsburgh Student Chapter: One of the best reports on student activities that have come my way is a recent communication from the University of Pittsburgh Student Chapter. It cannot all be briefed here, but the report tells about the "Big Brother" program and an outstanding seminar activity. Pittsburgh was the host this year along with Carnegie Tech to the ninth annual Mid-Atlantic Regional Convention. Well over seventy student chemical engineers attended. We cannot supply copies of the program, but Student Chapter counselors who are interested would do well to write to Dr. Charles S. Beroes at the University of Pittsburgh.

More on Local Sections: Hugh Guthrie, who is vice-chairman of the Program Committee and a member of the Career Guidance Committee, also planned an interesting program of college liaison for the New York Section, which is reported here so that other Local Sections may follow the same path. . . . Panel discussions were arranged by members of the New York Local Section with the Student Chapters of four engineering colleges in the New York area. The preliminary overture was made to the Student Chapter counselors, who in turn notified the Student Chapters that a panel for discussion of various types of engineering work was available. . . . Areas of work covered by the panelists were Research and Development, Design, Sales, Plant Operations. New York will probably continue this program next year.

F.J.V.A.



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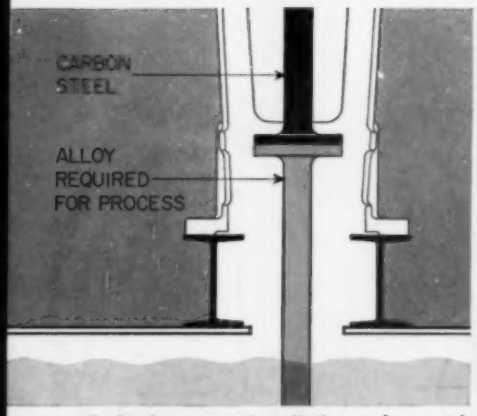
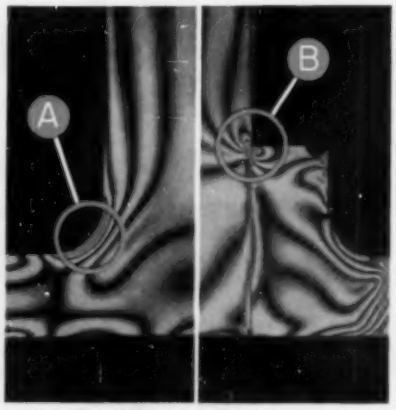
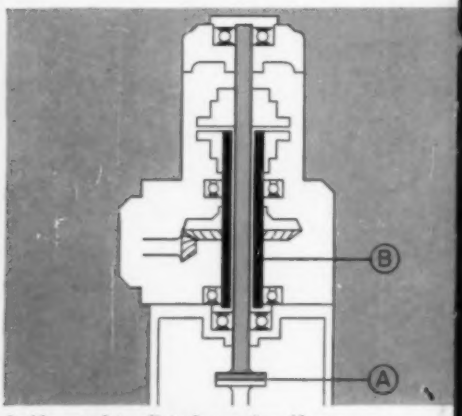


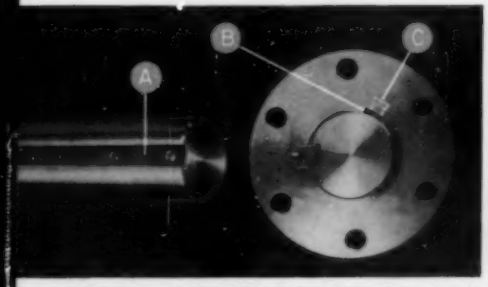
1. Get lower-cost installation, upkeep with two-piece shaft. Standard on open-tank units (available with closed-tank units, too), lower section is alloy required for process; upper section can be inexpensive carbon steel. Rigid coupling has rabbeted joint assuring accurate alignment.



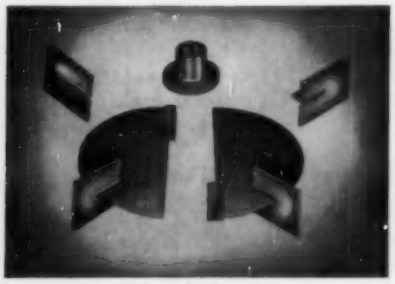
2. You get twice the strength of conventional shaft couplings with LIGHTNIN deep-welded coupling (A). Not one of these couplings has ever failed in service. Polarized light shows how machined and polished radius eliminates stress concentration found in conventional coupling (B).



3. No need to disturb gearing if you ever want to replace a LIGHTNIN shaft. Lower shaft is unbolted at (A). Upper shaft slides out of hollow reducer quill* (B). Gears remain untouched—cannot get out of line. When new shaft is installed, shaft alignment is automatic. *Patented



4. Save time positioning impellers. Standard 18-inch shaft keyway (A) provides seven positions (more if you want)—saves you cost of special machining. Also note shallow extra keyway (B) for impeller hub setscrew (C). It permits impeller to slide freely, even if shaft is burred.



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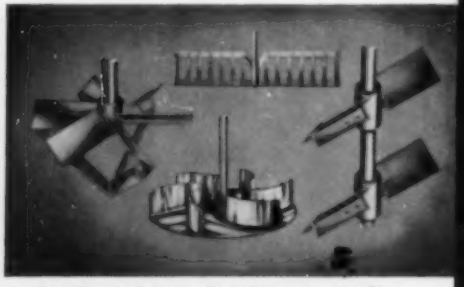

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